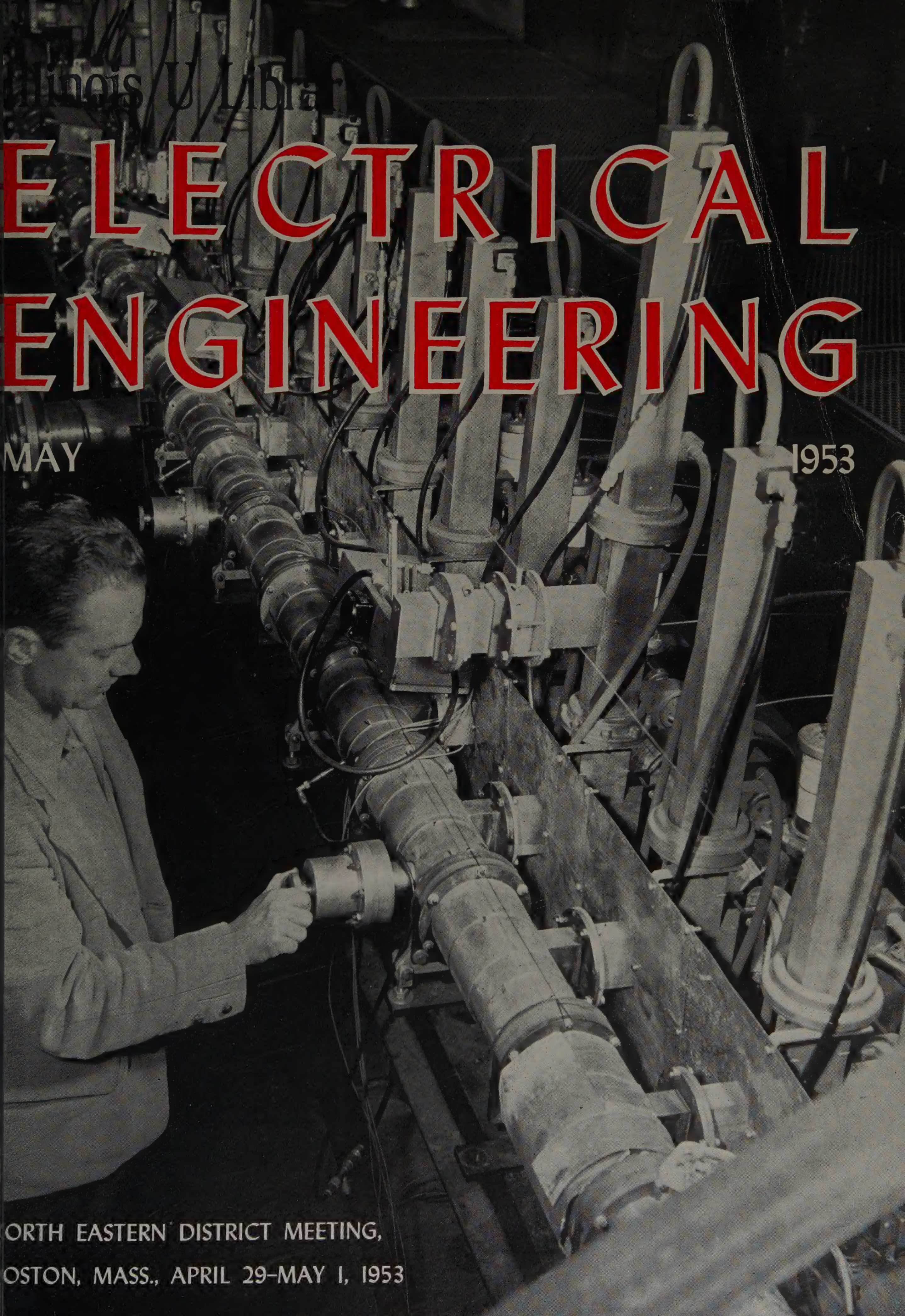
ELECTRICAL ENGINEERING

MAY 1953



ORTH EASTERN DISTRICT MEETING,
OSTON, MASS., APRIL 29–MAY 1, 1953

ELECTRICAL ENGINEERING

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The Cover: Dr. Arthur F. Kip, assistant professor of physics, demonstrates how each section of the 21-foot-long 17,000,000-volt linear accelerator now in use in the Laboratory for Nuclear Science and Engineering at the Massachusetts Institute of Technology is tuned. The new intricate high-energy machine, which is expected to produce radiation equivalent to that of more than 2 pounds of radium, will be used for nuclear research on the ultimate nature of matter.

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Management Development

L. A. RUSS

Effective development of management potential raises many questions and presents problems both to the individual and to the company. Not only must the individual make every effort to increase his effectiveness to his company, but the company also must have a definite program by which to guide and evaluate individual progress and development.

THE BROAD ASPECTS of management development can be meaningful and thought provoking both to members and to potential members of management.

In the minds of some there is the question, "What should an engineer do to analyze and develop his abilities so as to direct his progress?"; in the minds of others, the question, "On what does industry base its selection and development of people for important positions?" Possibly this article will indicate a desirable course of action.

The development of managers is not a new problem facing industry—surely the present status of most companies could not have been achieved without a great deal of attention to that important matter. Management has realized, however, that with its great expansion of facilities and the increasing complexity of business, it should have a planned approach with adequate tools so that the development of management people can be accelerated and proceed on a uniform basis throughout the organization.

Throughout industry the techniques of management development are receiving only now a belated recognition of formal organization. The widespread surge of interest is causing new techniques to be developed, and that expanding fraternity of people known as managers or directors of management development has no illusions about the enormity of its task in making certain that these techniques be effective, as well as practical in application.

Individuals are personally interested in knowing more about how a man advances in his organization. Management, on the other hand, is concerned with improved effectiveness on the part of men at all levels—beyond this management is continually seeking to identify individuals with management potential so that it can do something about better equipping them for advanced responsibility when that need arises.

The following discussion starts with an interpretation of industry's broad approach to the subject of management development. From this there readily may be elements that will suggest themselves to you as a manager or a potential manager in analyzing your abilities and in indicating a desirable action, either individually or for groups under your direction.

BASIC STEPS FOR INDUSTRY

THE GROWING EXPERIENCE of industry in the field of management development points to four basic steps that any company should take:

1. *It Should Determine Its Needs.* After satisfying itself that its organization structure meets its present needs, it should determine what each management position demands of a man. The actual description of each position should be translated into required qualifications.

Each position should be described as to its function, responsibilities, and authorities. More important, these elements should be thoroughly discussed between the individual and his supervisor so that the utmost in common understanding of aims and objectives can be realized. This should assure a proper assignment of all required functions of a department and enable supervision not only to direct action better but also to evaluate performance properly.

Requirements for each position—education, background, experience, personal characteristics—should be established. These are the basic qualifications that any individual should have before he would be considered eligible as a candidate for the position. If these requirements are followed realistically, men will be able to develop more easily into their assignments, and responsibilities can be apportioned with greater confidence.

2. *It Should Analyze What It Has.* The company should appraise the qualifications of its present and potential management personnel with respect to: adequacy in present position; deficiencies that should be remedied; and potentials that can be utilized to better advantage.

In the appraisal of a man's performance of stated responsibilities, consideration should be given to the results he obtains, the methods he uses to get those results, and the adaptability of his personal qualifications to the situation he holds. A proper evaluation would point up a man's best results, best methods, and best personal attributes, as well as pin point those which constructive action will help him to correct. The determination of the facts of such an appraisal should be a matter of multiple judgment by superiors who have knowledge of the man and his work.

Appraisal of performance is not complete without an objective review with the man being appraised. Honest recognition of accomplishment, together with better guidance and plans to improve areas of difficulty or omission, are essential to a healthy operation.

Evaluation of potential and readiness for advanced responsibility as a fundamental part of appraisal is also a

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matter of multiple judgment and suggests utilization of available time to best possible advantage in better equipping men for such responsibilities.

3. *It Should Inventory Its Management Resources.* With positions adequately defined and individuals properly evaluated, it is in a position to take inventory—by balancing its needs against its resources and projecting requirements and potentials into the future, it will be able to chart its course on a sound basis and be able to meet better the challenges that lie ahead. Many companies make use of Replacement Tables as a guide in determining their course of action.

4. *It Must Activate a Program of Guided Development.* On the basis of findings in the preceding steps, it must take appropriate action to remedy any current deficiencies in order to meet its present and future needs. Where potentials exist, correction of deficiencies and broadening of background and experience must be as objective as possible. Development is primarily individual in nature; it should stress better understanding and performance of function, as well as broadening of experience and background. There are many things that can be done, and, strangely enough, the majority of them are not by group training methods.

Although there are many variations in the approach to this important subject, most management development programs have these objectives in mind.

SUGGESTIONS FOR INDIVIDUAL HELP

DOES THIS SUGGEST ANYTHING that you can do, whether or not your company has such a program?

Look at your job; it may never have been spelled out for you. Write down just what you feel to be your duties, responsibilities, and objectives, then at an opportune moment, review it with your boss—he may suggest additions or changes—and make certain that both you and he have a common understanding of what is expected of you.

Next, sit in your boss' chair (in your imagination) and take an honest look at yourself as he sees you. Ask yourself: "Is this man who reports to me as good in his present job as he might be? Is he growing, or standing still? If I were promoted tomorrow could I conscientiously recommend him for my job?"

Here are some of the questions bosses ask as they discuss the various possible candidates:

1. Is he intensely interested in his work or merely in his pay?
2. Does he get along well with people?
3. Does he manage his life well—that is, does he live within his income; use his free time wisely; and keep his appetites under control?
4. Does he think of the welfare of his customers and associates before he thinks of his own, or is he always looking out for himself?
5. Does he co-operate with those above and below him as a good member of the "team," and cheerfully put his shoulder to any wheel that needs to be turned?
6. If he were given the bigger job that is open, would he do everything within his power to make those under him more successful, and build up a successor for his own job?
7. Is he big enough to learn from his mistakes?
8. Has he been getting ready for a bigger job?

These test questions will bear careful study. The last one is particularly important—more important than most men seem to realize.

The results you get from your work efforts have a bearing on the over-all success of the department you are in. The methods you use to get results are management qualifications. Do the methods you use enable you to get the best results?

This is, of course, the best form of self-appraisal. Any man who will do these things is likely to be surprised some day, and usually sooner than he dreams, by being selected for a bigger job, perhaps his boss', perhaps to fill a requirement in some other department.

Next, you can do more than anyone else about planning your own development. If there is some requirement of your own job or your boss' job in which you lack education, now is a good time to start studying. You should come to the conclusion that education is a journey, not a destination, and when you stop studying, your growth stops as well. How you handle the responsibilities of your present job is the best indication as to whether you can handle more.

The questions that may have been raised by these suggestions cannot be answered by anyone else but yourself. It is for you to determine whether it is worth the effort.

INITIAL REACTION TO A PRACTICAL CASE

IT IS INEVITABLE that a review be made of what we in the Westinghouse Electric Corporation practice in our own company. After an intensive period of research and trial we have placed in operation a Management Development Program based on the fundamental steps outlined earlier. The program was introduced over a year ago, and is applied to all levels of management throughout the entire company, encompassing more than 5,000 individuals.

As we introduced the program we came to the realization that there were really two phases to go through; the first was procedure and the second, a follow-through.

It was obvious that the first three steps, position specifications, appraisal, and inventory, although developmental in themselves, were fact-finding devices which could establish a firm base on which to build a real effort in the direction of developing management personnel.

Management, in completing the procedures with their problems, solutions, reaction, and evaluation, reflected a broad recognition of timeliness and value, and individuals reflected a spontaneous enthusiasm for the opportunity to define specifically their responsibilities, and even more so to discuss their over-all performance with their superiors. The reaction of the individual pointed up a widespread neglect of these basic management fundamentals, and we have the feeling that even if no further action is taken the time spent to date has been well worth the effort.

GUIDING THE DEVELOPMENT OF MANAGEMENT PEOPLE

IT IS THE SECOND PHASE, that of constructively using the vast amount of data developed from the procedures, that undoubtedly will be of more specific interest. What

we do in guiding the development of management people is in our minds the most important phase of our program. We feel that we have a fair start in this direction but fully realize that we have much to learn before we can draw any great measure of satisfaction from it.

It is generally agreed that development of personnel is logically a responsibility of the line organization. In any company with plants and management groups all over the country, there is not really too much that a headquarters' group can do to help them with this responsibility other than to approach the matter broadly and suggest specific courses of action. This we did when we first introduced the program throughout the company. However, as the procedures were completed in unit after unit, we began to get the reaction, "We expect to receive a program of follow-through action from you."

This reaction was not wholly unexpected. We had begun to develop a few ideas of our own and also had learned much from many companies in industry that had made constructive efforts in this direction. We were having difficulty, however, in determining how they might be related to our program until we awoke to the realization that the procedural data that were being developed could be the best source of information as to what we actually needed.

At that time, in the spring of 1952, some 2,300 appraisals had been completed, and we set about studying them from two points of view: (1) What did the appraisal committees say was needed for the individual, either to make him more effective in his present assignment or to help him qualify for an advanced responsibility; and (2) What did the individual, in his review of performance with his boss following the appraisal, say in regard to what help he desired from the company?

The results of this study are as follows:

	Action Recommended (Per Cent)	Help Desired (Per Cent)
1. Guidance	57.0	31.4
2. Management training	39.4	28.0
3. Special or committee assignments	20.7	3.6
4. Job rotation	17.1	4.5
5. Communications	6.8	16.5
6. Education	10.6	4.0
7. Training in specific fields	10.3	10.3
8. Public speaking	8.8	2.0
9. Technical societies	6.1	2.1
10. Suggested readings	1.0	1.5

From the study we feel that we have a clear-cut mandate to develop and supply devices which will handle the indicated needs of the company. Two very predominant needs are indicated, and our efforts will be weighted accordingly.

As one man's needs usually differ from those of another, it is the consensus of industry judgment that development is largely individual in nature. However, to supplement the procedures we have had so far, we believe we must have a positive program of action which recognizes both individual needs and group needs.

Let us consider individual development first. The foregoing table lists only a few of the many significant things that can be undertaken, but it allows us to focus attention on a few examples.

Rotation. This is a much misunderstood subject and, to be effective, should have definite objectives and a sound policy guide. It is a means of guiding the work experience of individuals, and we are well along in drafting a practical approach. We believe there are kinds of rotation that will make managers better in their present jobs, and that there are kinds of rotation that will broaden them for advanced responsibility. We believe that if we approach it practically it can be of great significance in the development of men.

Although rotation of men who are presently managers has been stressed, our thinking at this time also recognizes the need for broadening backgrounds at a much earlier stage of a man's career before he gets to be a manager. We have drafted principles that apply and are currently trying it out in one division where for a 1-year period nine men have been transferred from their specialty to an entirely different function; that is, from engineering to manufacturing, and so on. The results to date are very satisfying, and there is a great deal of enthusiasm for it.

Graduate Study Program. For many years we have had such a program in co-operation with leading universities. Throughout the years over 2,700 of our graduate engineers have enrolled, and over 250 have received master's or doctor's degrees. Its value has primarily been for technical advancement with little opportunity for training along business lines, except at an undergraduate level.

This spring, as a result of our program, we asked the University of Pittsburgh whether they would consider designing special courses in Business Administration to be taught on an advanced basis for graduate engineers. They enthusiastically accepted the challenge, and as a result the special night courses are now underway with over 150 of our men in the Pittsburgh area in attendance, of which a good percentage are management people.

We hope to extend this new program to all of the 11 participating universities in our Graduate Study Program and believe it might readily answer a widespread need in industry.

Advanced Management Programs. Many are familiar with the Advanced Management Programs at Harvard University, University of Pittsburgh, and Columbia, Stanford, and Northwestern Universities. These are significant development opportunities for high potential management people to be set aside from their regular duties for periods ranging from 4 to 13 weeks for an intensive review and study of the broader concepts of management. Within the last 2 years we have increased our participation to the point where we now send a total of 15 men per year. We look upon it as a very limited opportunity that we should utilize very selectively.

A by-product of having men attend these schools is to have others act in their position while they are away. This is a very desirable form of rotation, and for each man going to school, an average of three others are affected in the back-filling of assignments.

Other. In addition to the three items that have been highlighted there are many others that are significant in their own right and must be properly emphasized.

Some of these are public speaking, professional and technical societies, special projects, planned reading, and so forth. For example, we have had many requests for suggestions as to books in various phases of management. To answer this need we have prepared a booklet which we believe will stimulate pertinent reading.

NEED FOR INDIVIDUAL COUNSELLING AND GUIDANCE

ALL OF THESE THINGS and others, however, are only individual things that can be used in individual cases. We have felt that in order to implement properly individual development on a broad scale throughout the company, we would have to isolate one key common element around which all of the specific devices that have been talked about can revolve and be added as individual needs dictate.

The answer to that "key common element" appears to be that of counselling and day-to-day guidance. We believe that if this is done thoroughly and sincerely, all other elements that have been discussed are only supplementary. Actually, most of the individual things that have been mentioned are not new to our people, but the element of counselling should mean that their use can be better directed and more effectively tied in on a planned basis.

The problem of taking the simple term "counselling and guidance" and relating it to the conscientious planning necessary to an effective follow-through is undoubtedly the most important single element that needs to be gotten across to all levels of management people.

C. W. L. Foreman of United Parcel Service has this to say about it:

> Experience and our boss can be the best teachers. Since our boss is in charge of our experience, he is in the best position to assist us in learning from our experience. When he does this he is "coaching."
>
> Coaching is not something that is done but rather the manner in which administration and supervision are accomplished.
>
> One kind of coaching is related to the word experience: the planning, guiding, assigning of job after job in such a sequence at such a pace and in such a manner as to challenge the ability, stimulate the interest, and broaden the base of the individual.
>
> Another kind is related to the word learning: the assisting of a man to assure his meeting his experience successfully, to assure his gaining confidence and skill from it, to assure his relating it to his objectives.

As we look at it, there is a difference between performance discussion and coaching or counselling. The annual performance discussion, however, can be the first substantial step towards coaching.

Another way of looking at it is that all of us have faults or weaknesses of one kind or another. The appraisal step demonstrated that we have a device to identify the more serious ones. If that weakness be lack of tact, jumping at conclusions, getting along with others, or a host of others, how can individual counselling help to correct it?

E. G. Planty of Johnson and Johnson Company proposes a simple 4-step approach that appears to be quite far reaching. He says: 1. Identify a major weakness; 2. Determine its effect; 3. Analyze its cause; 4. Remedy by getting the subordinate to see and overcome the cause.

If this approach, or a combination of the ones that have been mentioned, has merit, it will be up to us to devise a means of promotion so that the basic principles of individual counselling can be gotten across uniformly throughout the company.

So much for individual development with all of the stress of importance that has been placed on it. It can affect the greatest number of our management people and have a degree of continuity which is essential to the longer range objective.

TRAINING IN MANAGEMENT

THE OTHER PREDOMINANT NEED as indicated in our study is for training in management and management principles—for people who are already in management positions. This, we feel, is more applicable on a group basis.

Our basic task appears to be to prepare a program of administrative management dealing with the functions and fundamentals of management such that it can be applied at the local level. Our preliminary work to date indicates that the program can be aided materially by applying the case discussion techniques used to such good advantage in the university Advanced Management Programs.

An additional need is to provide for the proper indoctrination of men into their first supervisory assignments. In too many cases it is assumed that the new supervisor knows how to manage, and his effectiveness suffers until he can fill that gap only through practical experience.

We have no illusions as to the vast amount of work that we need to do in this field. We do feel, however, that our program to date has been quite stimulating to the morale of our management group throughout the company and that we cannot afford to have other than an aggressive follow-through.

We believe the program provides a challenge, as well as an obligation, and that we all have a great deal to gain by a continued interest and conscious effort.

Safety Group Formed

Formation of a fire protection and safety research group, the first service of this type especially for Midwest industry, was announced recently by Armour Research Foundation of Illinois Institute of Technology.

Companies sponsoring fire protection and safety research at the Foundation will work to prevent fires or explosions from starting, to limit the spread of fire after it has started, to provide for prompt detection of fires, to provide for prompt extinguishment, and to prevent accidents. The Foundation is prepared to help develop new or improved products, materials, equipment, and instrumentation to meet basic fire protection and safety requirements and standards and to undertake research problems.

Television Coverage of the National Political Conventions

R. W. RALSTON
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B. D. WICKLINE

The first large-scale television coverage of both national political conventions occurred last year in Chicago and this presented many new problems to the telephone company of that city. Special video conductors and amplifiers were used in eight of the 19 channels to the Amphitheatre and microwave facilities for the rest.

IF ONE were to indicate in a single word the over-all characteristic of the late Democratic and Republican Political Conventions, it would be difficult to avoid choosing "quantity." From a political standpoint certainly at no other two events in recent history were manifest in comparable numbers, the candidates, the delegates, the committees, or the commentaries by seemingly limitless groups of reporters. Nevertheless, the most significant application of this word is to the means by which these candidates, delegates, and so forth, were presented visually to the American public during this period through television. The quantities of equipment and personnel, pooled by various sources in Chicago, Ill., during July of 1952 to provide this first nation-wide television convention coverage, were unprecedented, making the television camera as ever-present as was the microphone at previous conventions. Many occurrences during this period could be cited to illustrate this thesis, but perhaps none so graphically as the coverage of General Eisenhower, following his selection as candidate. Cameras were placed in his suite at the Blackstone Hotel, at various points near the exit from the hotel, along the street in front of the hotel, outside the Amphitheatre, and so forth, to cover every phase of his activity.

The provision, by Illinois Bell Telephone Company, of television facilities for this period represented no exception to the application of this word. As an operating company in the Bell System, it was their engineers' job to provide all television channels connecting various pickup points, such as the Amphitheatre, the Conrad Hilton Hotel, the Blackstone Hotel, and other points, to the network terminus in Chicago and also to provide nearly all the other local television channels which were used during this period.

Preliminary plans for the political conventions were formulated immediately after the International Amphitheatre had been officially selected as the site, at which time telecasters indicated that each would require two connecting channels. However, these plans were not crystallized until more detailed video requirements were received early in February 1952. These indicated that approximately 25 channels additional to those in use in the Chicago area at that time would be required during the month of July. Included were 19 channels between the International Amphitheatre—the primary source of convention activities—and the following locations:

1. The Merchandise Mart—the location of the studios of television station *WNBQ*, the Chicago National Broadcasting Company (NBC) outlet.
2. The Civic Opera Building—location of the studios and transmitter of television station *WENR-TV*, the Chicago American Broadcasting Company (ABC) outlet; also the transmitter location of station *WNBQ*.
3. The Hilton Hotel—a secondary point of convention coverage.
4. Number 2 Toll Office—the terminating point in the Loop area for video transmission to or reception from the cross-country network.

The remaining six channels extended between various miscellaneous locations in the Loop area.

This was an unprecedented request for service; it would double the number of channels then being provided by the company. However, this requirement was understandable in view of the broadcasters' plans to provide convention coverage for the entire day during the progress of the conventions. This would consist not only of programs originating at the Amphitheatre, but also from the Hilton Hotel, various convention headquarters, and from the network. Consequently, each planned to establish an independent master control point at the Amphitheatre, through which most of these programs would pass regardless of whether they originated at the Amphitheatre. Editing and switching of pictures would take place here prior to transmission for direct telecast to all network stations providing convention coverage.

A comprehensive review then was made to determine the most suitable means of furnishing the required service. In general terms, of the 19 channels originating or terminating at the Amphitheatre, it was planned to use special video conductors and video amplifiers for eight of the channels, and to use microwave facilities for the remainder. In regard to other locations, conductors would be used where installed or where a reasonably economic rearrangement would make them available. Microwave channels would be used for the remainder.

Revised text of paper 53-90, "Television Coverage of the National Political Conventions," recommended by the AIEE Committee on Television and Aural Broadcasting Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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CABLE

Before discussing the problem of providing special video pairs, a brief exposition will be made of the cable facilities for television service. Generally speaking, two types of conductors (pairs) are used with amplifying equipment for intracity television service. The first is the *PSV* pair, a special video pair. It consists of two 16-gauge conductors surrounded by polyethylene string and tape insulation and a double shielding of helically wound copper tape. This makeup provides excellent characteristics for television application such as relatively small loss, very low noise level, and excellent shielding. The *PSV* pair is placed within a protective sheath along with other conductors of its type and regular telephone pairs, thus constituting what is called video cable.

The second type is the ordinary telephone pair. This has from three to five times the loss of the *PSV* pair, thus requiring more amplification per channel and providing relatively high susceptibility to interference from other telephone pairs. Statistically speaking, paper pairs have relatively high ambient noise when evaluated according to television requirements. Use of these pairs is rapidly being discontinued as video cable is installed.

In regard to cable facilities, plans had been formulated independent of the convention for expansion of *PSV* pair in many areas of the city. For instance, it was decided to extend pairs south from the Loop to provide service to various theaters in the area for theater television, to connect to one of the new toll offices, and to establish service to miscellaneous pickup points in this area. These plans were to be implemented over a broad period. However, because the Amphitheatre was located near the path along which the south expansion would be made, it was decided to expedite its completion by convention time. It then would be necessary to add only a short length of *PSV* cable from the Amphitheatre to intercept the new *PSV* pairs, in order to establish the convention requirement of eight wire channels between the Loop area and the Amphitheatre. This would avoid an excessive capital expenditure for the convention alone.

Originally, a 4-pair *PSV* cable had been placed from a central office in the loop area (Wabash) as far south as the American League Baseball Park (Comiskey Park) located at 35th Street South. See Figure 1. Two of these pairs were looped through the park and extended farther south and west to the International Amphitheatre at 42d Street. The other two were left unused. This provided coverage to both locations.

The plan for expanding facilities south entailed the following:

1. Construction of a small building for housing video amplifiers to be known as Amplifier Station Number 1, located about 5 miles south of the Loop on the fundamental video wire route. The Amphitheatre lies just a few blocks west.

2. Placement of a 4-pair *PSV* cable from Wabash Central Office directly to the new amplifier station, bypassing Comiskey Park.

3. Extension of the original two unused pairs to Ampli-

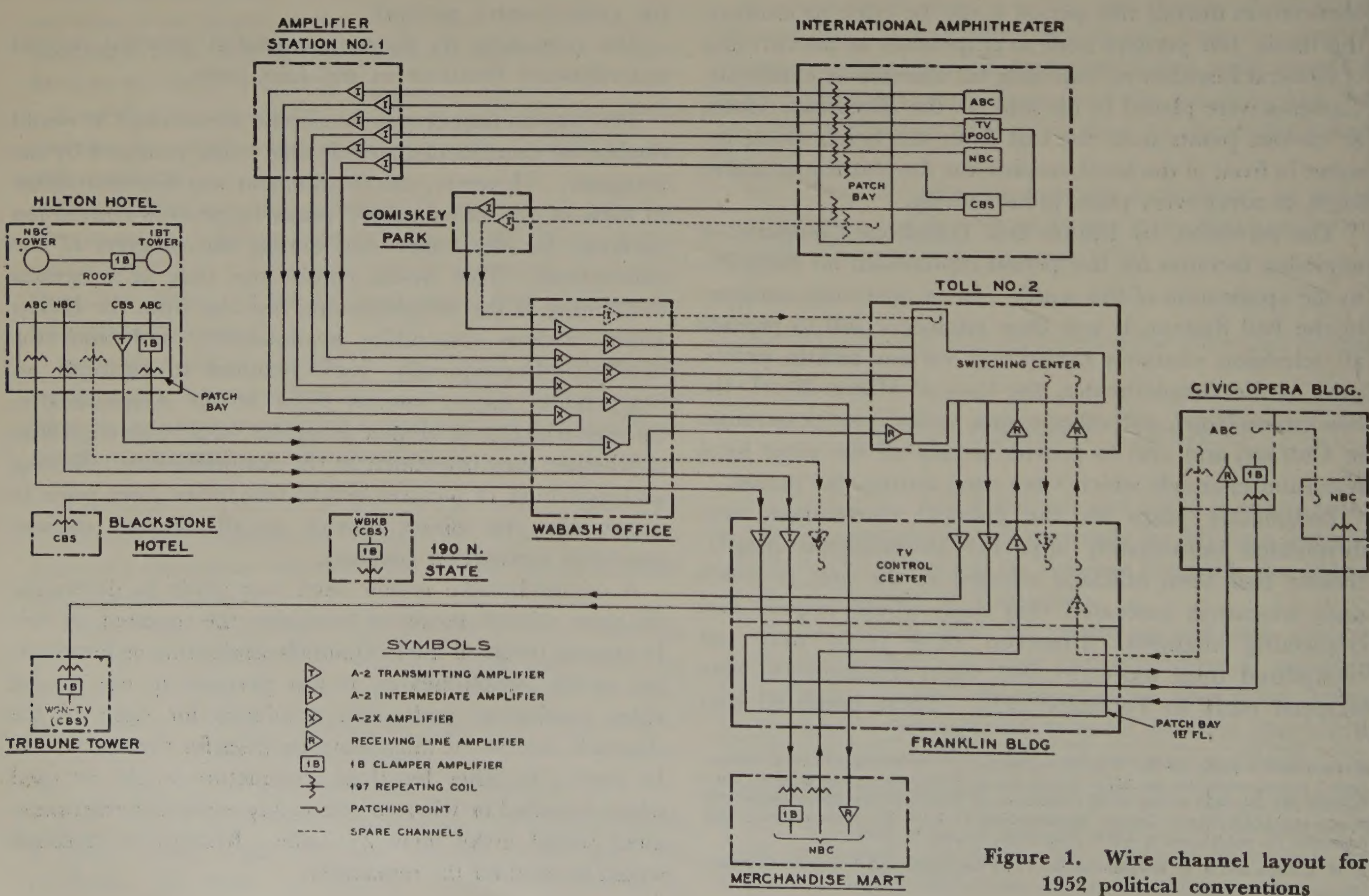

Figure 1. Wire channel layout for 1952 political conventions

fier Station Number 1, by-passing Comiskey Park. This then provided a total of six pairs to the amplifier station.

4. Placement of an additional 6-pair extension from the station to the Amphitheatre.

This provided the necessary eight pairs from the loop area to the Amphitheatre, two of which looped through Comiskey Park and did not extend through the amplifier station.

Plans were made also to install additional pairs in other parts of the city. Three *PSV* pairs were added to the two then providing coverage to the Hilton Hotel. Four *PSV* pairs were added to those serving the Merchandise Mart. Finally, very extensive rearrangements and additions were made at the Civic Opera Building, at some of our Loop Central Offices, and at Toll Number 2.

WIRE AND MICROWAVE EQUIPMENT

To clarify some of the equipment problems involved, some characteristics of wire video channels will be discussed.

A wire video channel consists of conductors, terminal equipment to permit connection to the broadcasters' equipment, suitable amplifying equipment, and a means of equalizing the conductor losses which vary with frequency. At the originating terminal, a means is required to convert from the unbalanced facilities (coaxial cable) of the broadcasters to our two conductor *PSV* facilities, each conductor of which has a like impedance to ground (balanced pair). Either a repeating coil or an amplifier may be used for this purpose.

The terminal equipment at the receiving location consists of the repeating coil just mentioned and a clamper amplifier. The latter consists of an amplifier and a clamper unit which maintains the voltage level of the signal at a fixed d-c value.

Amplification and equalization are accomplished using *A-2* amplifiers. Each consists of three components: an input amplifier, an equalizer panel, and an output amplifier. Both input and output may be adapted for connection to coaxial conductors or balanced conductors. The *A-2* amplifier can make up both gain and equalization on cable losses up to 65 decibels at 4 megacycles. In the case of *PSV* pairs, this permits a cable section of 4 miles between adjacent amplifiers.

To provide amplification and equalization on the new wire lines extending south of the Loop area for the convention period, a new item of equipment was made available, the *A-2X* amplifier. This has gain and equalization potentials in excess of the *A-2* amplifier, thus permitting adjacent amplifiers to be spaced $5^1/_2$ miles apart instead of 4 miles.

The additional gain and equalization are obtained by adding an additional amplifier to the *A-2* system and providing additional space for equalizers on the equalizer panel. Thus the *A-2X* provides gain and equalization on circuits up to 85 decibels of 4-megacycle loss as compared to 65 decibels for the *A-2* system.

Installations of these amplifiers were made at the Wabash Office in the Loop area and at Amplifier Station Number 1. This station was constructed at a location based upon the spacing which could be tolerated between adjacent *A-2X* amplifiers.

An item of terminal equipment developed for use at a number of locations in time for the convention was the receiving line amplifier. This item, which is most compact and more economical than the *A-2* amplifier, was designed for use at the receiving terminal of relatively short channels. It provides limited equalization and gain, obviating the need for *A-2* amplifiers on channels of 35 decibels of 4-megacycle loss or less. It is made up of a modified input amplifier from an *A-2* system, an equalizer panel, a special impedance-conversion device, and clamper unit. The impedance-conversion device is necessary to change the equalizer panel impedance to that of the clamper.

Because of the critical need for *A-2* amplifiers during the convention period, installations of these receiving line amplifiers were expedited at the Civic Opera Building, the Franklin Building, and Number 2 Toll Office. Several portable units were also ordered for use where necessary at miscellaneous locations.

Installations of repeating coils and clampers were made at the Hilton Hotel, International Amphitheatre, and other locations. Portable clampers were ordered for use at miscellaneous locations.

In order to provide the required number of microwave channels, it was necessary to obtain microwave equipment from other operating companies. Accordingly, four *TE*-type microwave equipments were rented from the Wisconsin Telephone Company and two RCA (Radio Corporation of America) units were rented from the New York Telephone Company. The *TE*-type equipment operates at 4,000 megacycles while the RCA operates at approximately 7,000 megacycles. Together with the equipment owned or ordered by our company, this provided a total of six *TE*- and nine RCA-type equipments. Eleven of these units were planned for use between the Amphitheatre and various Loop locations, while the remainder were to be utilized as maintenance spares and for the provision of regular and unforeseen requirements occurring during the convention period. Various test and maintenance equipment, such as oscillators, signal generators, and measuring devices, were also obtained for the operation of both wire and microwave channels.

SPACE

Generally it is company policy to have the majority of the video channels extend through the Loop Central Office (Franklin Building) for control and monitoring purposes. As applied to a typical microwave pickup, this means that the microwave transmitter is located at or near the pickup point, while the receiver is located at one of our tall central office buildings in the Loop area. From this point the signal is transmitted to the broadcaster by a wire channel through the Franklin Building. However, because of the unusual nature of the demand for channels during the convention, it was necessary to establish microwave circuits directly between the pickup point and the broadcasters' location since sufficient wire

Figure 2. Microwave space on roof of International Amphitheatre

lines were not available. To implement this plan it was necessary to secure space and roof rights at the following locations:

1. The International Amphitheatre (all microwave and wire channels).
2. The Civic Opera Building (ABC and NBC microwave channels).
3. Merchandise Mart (NBC microwave channels).
4. Hilton Hotel (microwave and wire channels).

The International Amphitheatre, where 11 microwave channels and eight wire channels would originate and terminate, imposed the most unusual requirements. Here it was necessary to secure space for 11 microwave equipments on the roof, space for associated control equipment within a distance of 200 feet of the roof, and, finally, space for amplifiers and other equipment for the wire channels. Surveys were conducted to determine a location on the Amphitheatre roof providing line-of-sight coverage to each of the locations in the Loop area requiring a microwave channel. Based upon these surveys, which in som instances required microwave-path clearance tests, th northwest penthouse roof of the Amphitheatre was selecte This afforded sufficient space for 11 equipments and pr vided the necessary clearance to each of the Loop location Due to the fact that different types of equipment were t be used, each requiring somewhat different mountin arrangements, a special platform was constructed for th roof location. See Figures 2 and 3. Three *TE* equip ments required vertical supports while the other *TE* an the RCA equipments were mounted both on the mai platform level and a second level above this at sufficie heights to provide parabola clearance.

The earlier *TE*-type transmitters were so constructe that the length of cable connecting the radio-frequenc equipment to the control equipment was limited to 1 feet. Since one of these units was used, it was necessar to place the control equipment near the radio-frequenc equipment. Since it was inconvenient to construct shack close enough to the radio-frequency equipment t permit use of such a short connection, the radio-frequenc equipment was separated from the antenna using trans ducers and coaxial cable giving an additional 30 fee separation. See Figures 2 and 3.

The location for associated microwave control equipmen also had to be satisfactory for placing the amplifyin equipment for the eight wire channels. This then woul permit one centralized location within the Amphitheatr where complete control could be obtained over the 1 video channels. A large room immediately below th microwave roof location was selected and in Figure 4 i shown the equipment layout in this room. Each oscillo scope was associated with an RCA microwave receive output. Portable oscilloscopes not shown in the diagra were used as needed for the *TE*-type outputs. Th 197 coils used for the wire circuits were mounted on patch bay, shown in Figure 5.

This patch bay was the central control point for a

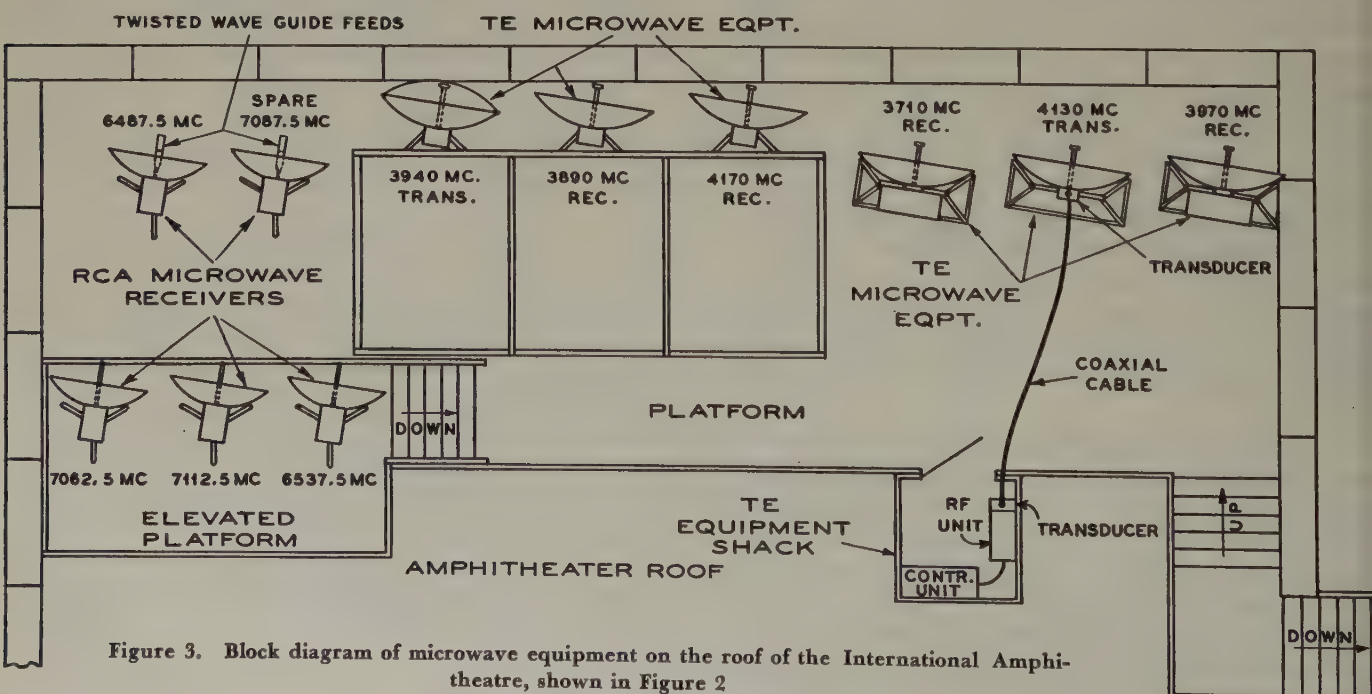

Figure 3. Block diagram of microwave equipment on the roof of the International Amphitheatre, shown in Figure 2

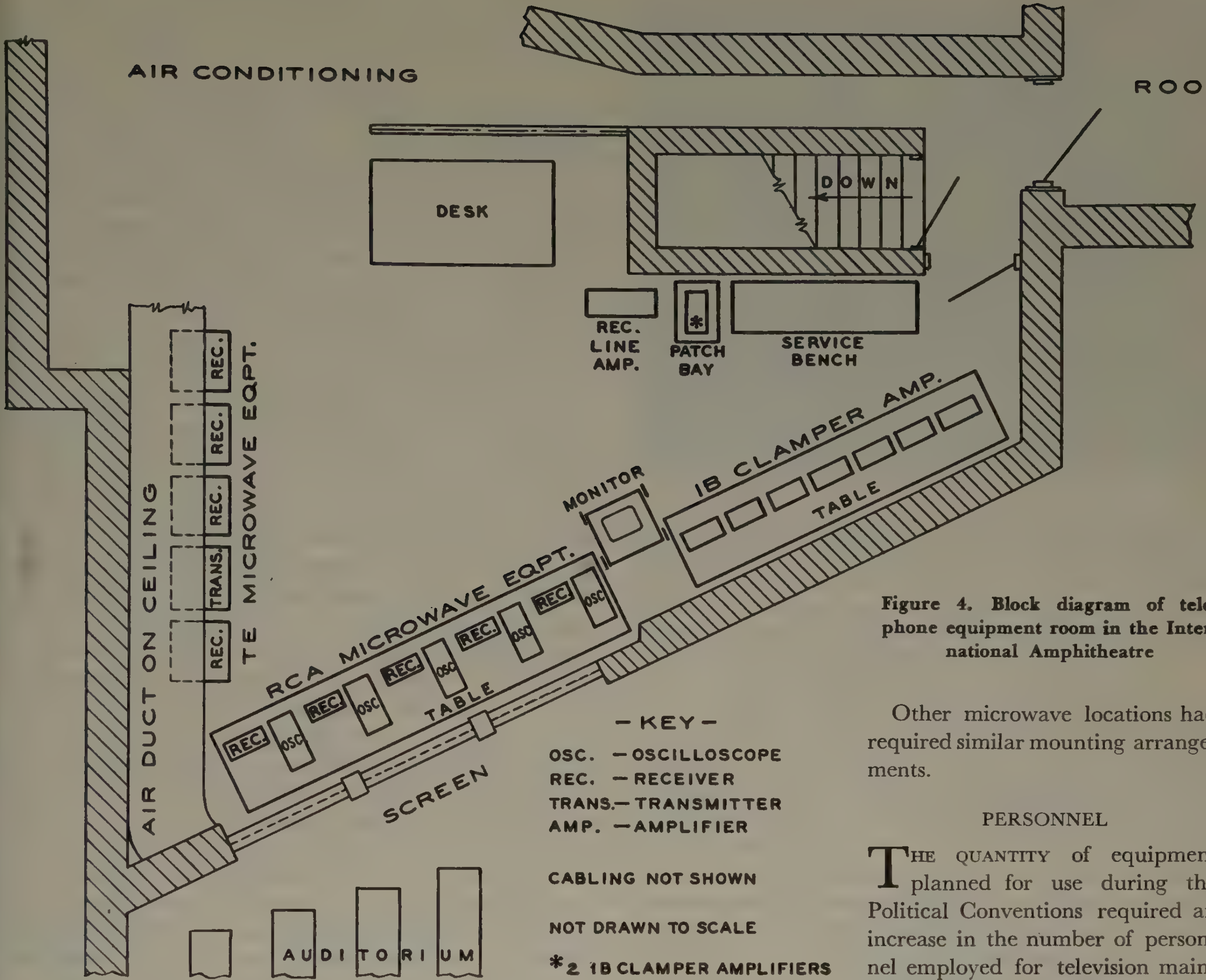

Figure 4. Block diagram of telephone equipment room in the International Amphitheatre

the channels at the Amphitheatre. Electrically, it was located between the broadcasters' and our equipment and was designed primarily to permit a rapid switching of circuits or equipment in the event of trouble or changes in requirements. Coaxial leads were used to connect the various broadcasters' master control rooms on the second floor to this bay. The input and output of all equipment located in the room was connected to the patch bay with provision for monitoring at every point. This facilitated quick isolation of trouble.

At the Merchandise Mart (see Figure 6), a special platform was constructed incorporating the same features for mounting the *TE* equipment as those used at the Amphitheatre. *TE* equipment was assigned inasmuch as the broadcaster used RCA equipment at this location which operated adjacent to our RCA band. It was felt that our use of RCA equipment might result in the introduction of mutual interference, especially during periods of tuning when high modulation levels were employed.

A power and ventilation room immediately north of the platform was used to house the control equipment. From this location, coaxial cable was run to the *WNBQ* studios located on the floor below.

Other microwave locations had required similar mounting arrangements.

PERSONNEL

The quantity of equipment planned for use during the Political Conventions required an increase in the number of personnel employed for television maintenance and installation. The normal force of 15 men was increased to 45 during this period with a proportionate increase in supervision. Because most of these new personnel had no previous television background, it was necessary to establish a training course to include both theoretical and practical aspects of television installation and maintenance. This training period was begun some 2 months prior to the first convention and was approximately 4 weeks in duration. This permitted all personnel to have some practical training on the equipment before the convention started.

DESIGN

The description given in the preceding paragraphs generally applied to preparatory work such as cable installation, equipment design, and so forth, based on estimates of circuit requirements received from the broadcasters. As actual orders for the channels were received, detailed circuit design was begun. Figures 1 and 7 depict the final layout for both microwave and wire channels. It should be emphasized that only channels ordered specifically for the convention are included in these layouts. Thus, Figure 1 does not include, for purposes of simplicity, all of the channels available to each broad-

Figure 5. Equipment room at the International Amphitheatre. The patch bay showing jacks and plugs is on the left behind the cabinet. Above this is shown the rear of the 197 coil installation and the 1B clamper amplifiers appear on top and bottom of the bay. Portable monitor and oscilloscope are shown on dolly and on the table are some of the 1B clamper amplifiers. A video monitor is on the right

caster which were in regular use during the convention period. This would include for instance, in the case of *WNBQ*, six additional video channels from the Merchandise Mart used for regular network loops, remote studio pickups, and studio transmitter links, and, in the case of other broadcasters, a proportionate number of similar channels. Microwave facilities in normal use are also not included. As is evident, wire facilities extending to the Amphitheatre all employed equipment for transmission from this location. This was done to facilitate quick rearrangement

Figure 6. TE microwave equipment on the roof of the Merchandise Mart with mounting details shown

of channels in the event of trouble and to simplify equalization and maintenance problems. In addition, it was desired that each network feed from the Amphitheatre be provided with uniform facilities.

An extremely important consideration in establishing both wire and microwave channels was the provision of spare facilities. The quantity of channels which would be used during the convention was unprecedented in our previous experience and indicated that spare facilities should be available wherever possible. (These facilities were employed for our own use, however, and were not assigned to any particular broadcaster.) A study of Figures 1 and 7 will indicate that spare facilities were available in both directions between the Amphitheatre and Toll Number 2, between the Hilton Hotel and the Television Control Center* (TCC) in one direction, and between the Civic Opera Building (either ABC or NBC) and the Television Control Center in one direction. Additional facilities were available between the TCC and Toll Number 2 in both directions. Not included in the illustrations are channels available from the TCC to each broadcaster for normal program use which could be used as additional paths during the convention period. Spare channels were equalized to each patch point so that many channel rearrangements were possible in the event of a failure of a particular section. To give an example, if one of the microwave circuits failed between the Hilton Hotel and the Amphitheatre, a spare wire channel between the Hilton Hotel and the TCC could be patched to a spare microwave channel between the TCC and the Amphitheatre to re-establish the circuit. This could be done in a matter of seconds in the event of a failure.

All channels were not, however, provided with spare facilities as is evident in Figures 1 and 7. The cost incurred in providing a complete spare system would be prohibitive and could not be justified on the basis of future usage.

Several problems were presented in the design of the microwave channels. One example was in regard to the use of frequencies for operation of the RCA microwave units; our license permitted the use of only three frequencies for broadcast pickup purposes. Since five RCA units were planned for use on essentially parallel air paths to the Amphitheatre and others were in use on air paths likely to present interference problems, special temporary authority was obtained from the Federal Communications Commission (FCC) to use frequencies licensed for closed channel operation (theater television). To reduce further the possibilities of mutual interference on adjacent channels operating over these parallel air paths, special twisted waveguide feeds were employed to rotate the polarization of the microwave energy by 90 degrees. See Figure 3 (upper left). This virtually eliminated coupling with other units operating with normal polarization. These feeds were employed on equipment on the center frequency of the broadcast microwave band and on one of the low-band (theater television) frequencies. They were particularly useful during line periods when modulation levels were somewhat higher than normal.

* A location within the Franklin Building containing video amplifying and monitoring equipment.

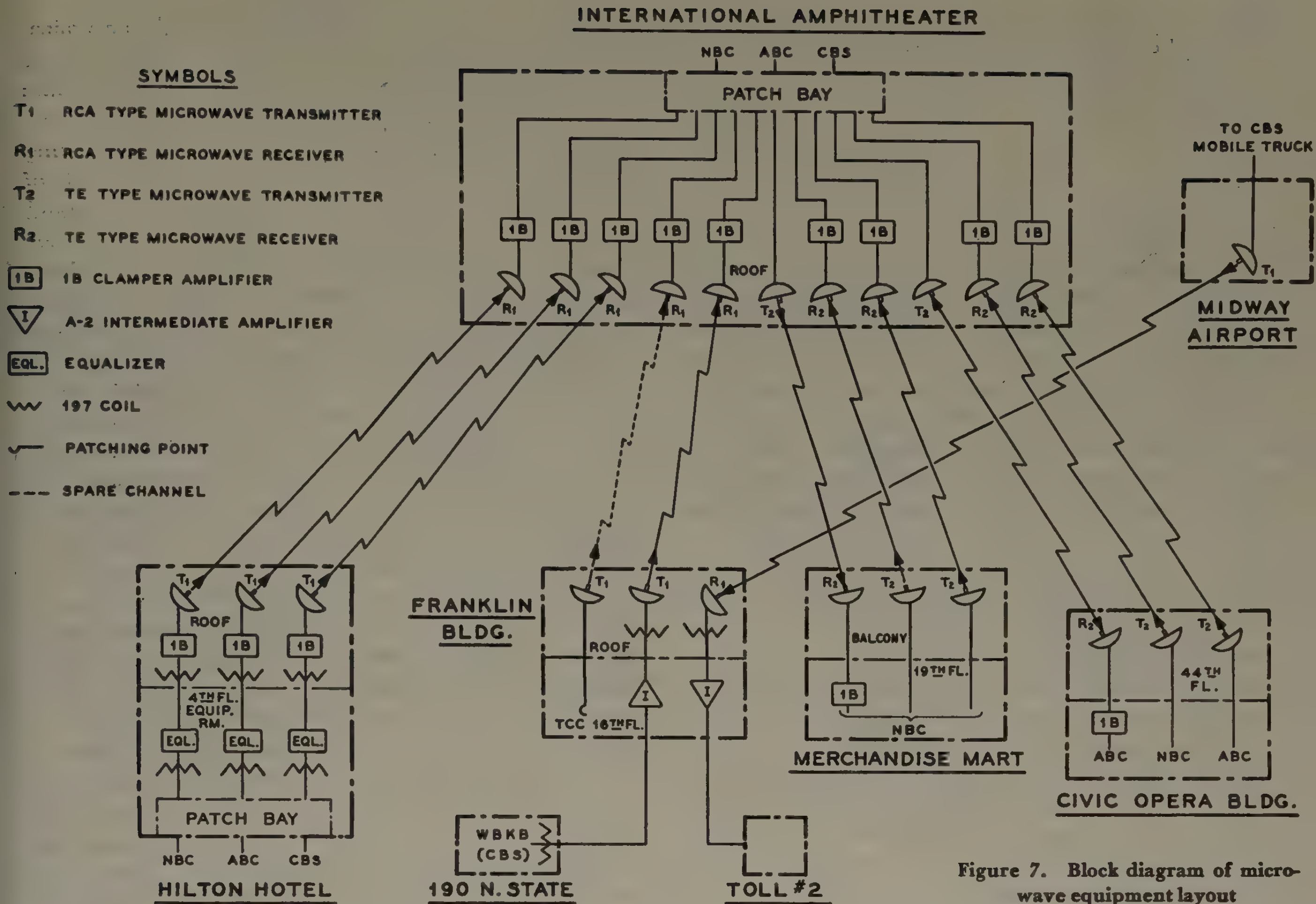

Figure 7. Block diagram of microwave equipment layout

OPERATION

Most troubles occurring during the period of both conventions were of an ordinary nature such as vacuum tube failures, power failure, and so forth. However, one particularly aggravating trouble involved equipment grounding at the Amphitheatre. This was evidenced as a 60-cycle signal superimposed upon the video signal, and was objectionable only in so far as additional equipment was required. Considerable apprehension was felt lest the interference become great enough to affect proper clamping. Without going into the many details of time-consuming efforts used to reduce this interference, it is sufficient to say that the trouble arose because of the differences in ground potentials between our location and the broadcasters' location. It does seem imperative in the future that installations of this kind should be planned in advance by the various organizations concerned, and that methods of establishing a suitable ground system be agreed upon.

During the convention period, a number of requests were received for channels to miscellaneous locations such as the Municipal Airport, hotels, depots, and so forth, with very little advance notice, requiring close co-ordination of Commercial, Engineering, and Installation Departments. In one instance, a request was received one evening for a circuit from the airport for the pickup of the arrival of President Truman's airplane, the *Independence.* A circuit to this location had been established previously on several occasions, using microwave equipment. However, recent construction work on a new hangar on the airport grounds had blocked our normal microwave path to the Loop area. Therefore, a new route had to be cleared quickly. Our mobile television truck was maneuvered to a point on the field where a line-of-sight path was available and the microwave equipment was placed on the top of the truck. Transmission was good but was subject to interruptions by airplanes taxiing across the path. A conference with ground crew officials at the airport assured us that the path would be kept clear even though it meant some last-minute changes in plans for locating the *Independence.*

During the conventions, all responsible groups were organized to take action to minimize service outages which would naturally eventuate from the use of so much electronic equipment. However, months of preparation, planning, and training proved of great value. Of approximately 400 channel hours of program time which were provided to telecasters, only 9 3/4 minutes were lost, a percentage of 0.04. Program time is defined in terms of intervals during which the channel intelligence actually is being telecast. This does not include lost channel time, another index used to gauge performance, which included failures occurring during the period the channels are ordered by the customer for line-up or stand-by, regardless of telecast. This amounted to some 10 hours of a 4,000-hour total. Nevertheless, judging by public reaction to the conventions, there were some viewers who might have preferred to see a less impressive record.

Negative-Sequence Currents for Line-to-Line Faults

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THE RECENT REVISION of the American Standards Association Standard for Rotating Electrical Machinery, *C50*, short-circuit clause specifies requirements for synchronous generators during 3-phase, line-to-ground, and line-to-line short circuits. A generator operating at rated kilovolt-amperes and power factor, with fixed excitation at 5-per-cent overvoltage, must be able to withstand a 3-phase short circuit at its terminals. For line-to-ground short circuits, the maximum instantaneous current must not exceed that obtained under a 3-phase short circuit.

The requirement referring to line-to-line short circuits pertains to the allowable negative-sequence current which can flow in the generator. The revised clause defines this generator limitation in terms of negative phase sequence current in machine per unit stator current (I_2) and the duration of the fault in seconds (t). Machines must be able to withstand without injury an integrated product of I_2^2t of 30 for turbine-generators, synchronous condensers, and frequency-changer sets, and 40 for hydraulic-turbine and engine-driven generators. For values exceeding 200 per cent of the foregoing values, serious damage should be expected.

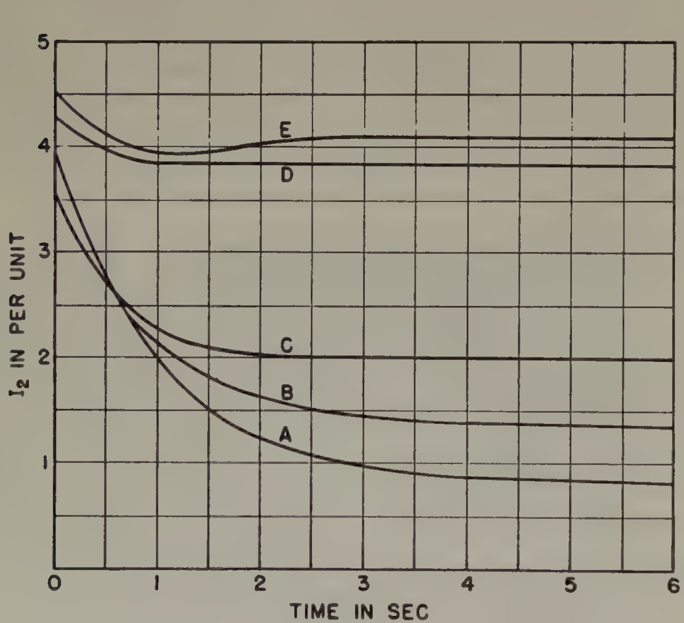

Figure 1. Generator negative-sequence current for a line-to-line fault on terminals of generator with no step-up transformer

A—Rated voltage, no load, machine isolated
B—Rated voltage, full load 0.85 power factor, machine isolated
C—Generator with automatic voltage regulator to boost exciter to ceiling, full load 0.85 power factor, machine isolated
D—Generator with automatic voltage regulator to boost exciter to ceiling, full load 0.85 power factor, machine in parallel with 10-per-cent system reactance to an infinite bus
E—Generator with automatic voltage regulator to boost exciter to ceilings no load, machine in parallel with 10-per-cent system reactance to an infinite bus

In order to determine the equivalent value of I_2^2t, it necessary to obtain the negative-sequence current as function of time. For heating effects, the subtransien negative-sequence current is of too short duration to requir its consideration. Therefore, only transient and sustaine negative-sequence currents need be calculated.

This article presents results of calculated negative sequence current in a generator under line-to-line fault Only line-to-line faults were studied because they resul in the highest magnitude of negative-sequence current in generator. Cases were studied which determined th effects of load, external system reactance, and generation and the presence of automatic voltage regulators.

The shape of the curve of negative-sequence curren plotted as a function of time for a line-to-line fault at th terminals of a generator under various conditions is illus trated in Figure 1. The system conditions for the curve are given in the caption of the figure. The generator wa assumed to have the following characteristics: $X_d=1.4$ per unit, $X_d'=0.15$ per unit, $X_2=0.10$ per unit, and $T_{do}'=$ 6 seconds.

These curves show that the negative-sequence com ponent of fault current of an isolated machine has a sub stantial decrement from the initial to final value. How ever, a machine with automatic voltage regulators an connected to a large system has very little decrement, i which case the steady-state value of negative-sequenc current can be used to find rotor heating during fault

The curves of Figure 1 also illustrate the effect of loa on the fault current. When a machine is under manua excitation control, the presence of load causes a highe excitation to exist prior to the fault and results in a highe fault current. If the generator has automatic voltag regulators, the load effectively holds down the generato voltage and thereby reduces the fault current.

Curves similar to Figure 1 were calculated for a wid variation of system conditions with and without voltag regulators. Results of these studies lead to the conclusion

1. For a generator under manual excitation contro the initial value, decrement, and sustained value of th negative-sequence current must be considered in determin ing the equivalent current. This equivalent current used to evaluate allowable line-to-line fault duration tim in line with ASA *C50* Short-Circuit Requirements (Re vised Clause).

2. For a generator under automatic voltage regulatio the sustained value of negative-sequence current can b used to determine the equivalent current.

Digest of paper 53-37, "Generator Negative-Sequence Currents for Line-to-Li Faults," recommended by the AIEE Committee on Relays and approved by the AIE Technical Operations Committee for presentation at the AIEE Winter General Meetin New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Tran actions*, volume 72, 1953.

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The Role of the Supervisor in Safety Work

W. H. SENYARD

No factor in accident prevention is more important than good supervision. The success of a safety activity, as well as most any other operating matter, will vary in proportion to the quality of supervision. Certain requirements are needed by the supervisor, not only to prevent accidents, but also to discharge his other obligations and responsibilities to his company, his customers, and his fellow workers.

AN ACCIDENT prevention program cannot be successful without good supervision. There are many factors that must be right to achieve a low employee injury rate, but none is more important than good supervision. Inadequate or misdirected supervision will more than offset an excellent program, whole-hearted company endorsement and backing, and employee interest. Those things are all essential too, but the success of a safety activity, as well as most any other operating matter, will vary in proportion to the quality of supervision. Observation has shown that the employee injury record of a group is a good index or yardstick of that supervisor's achievements in many ways.

What should a supervisor be like, not only to prevent accidents, but to discharge the many other obligations and responsibilities that are his? What is expected of him by the members of his group? For an answer, assume for a moment that you are helpers, mechanics, electricians, or something of the kind—not a supervisor. What would you expect of your supervisor if you were in such a category? First of all he must be fair, sincere, and honest. In addition, he should be understanding, patient, and tolerant. Commendable as these traits are, they are still not sufficient to qualify a man as a good supervisor. He must be able to select, train, and lead. And here is where so many supervisors fail, particularly in proper selection and adequate training. Your confidence in him should be such that you are willing to place your life in his hands, and to know that his decisions will be well thought out, and that your and your family's interests will be not only respected, but protected by him.

You cannot have effective accident control in a group that is beset with noticeable discord, distrust, and low morale. Accident prevention brings into focus the effectiveness of the team play of a group.

This does not mean that a group with good employee morale, and good leadership, never will have accidents. Unfortunately such a statement could not be made with assurance and finality. However, it can be said most assuredly that those groups that are lacking in good leadership and accordingly have low morale are much more likely to have accidents. And it may be added, merely as an opinion, that their performance records in other categories, in all likelihood, will be unfavorable also.

Revised text of a conference paper presented at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Recommended for publication by the AIEE Committee on Safety.

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You would like to feel that you could go to him and discuss in confidence your on-the-job problems, and lean on him for advice for off-the-job problems.

You would like to know that he is not going to play favorites; that if you do your work the way it is supposed to be done, if you measure up to the various performance standards, you will receive the same consideration for promotion and advancement when the opportunity comes along as anyone else who may have similar qualifications.

THE SUPERVISOR TO HIS COMPANY AND CUSTOMERS

NOW LOOK AT THE SUPERVISOR'S job from two other angles: the company and the customer.

What is expected of a supervisor by his company? Briefly, the company expects him to have the knowledge, ability, capacity, desire, and enthusiasm to do the job—whatever it is—assigned to him. He should be co-operative with company policies and attempt to interpret and explain them to the members of his group. He should attempt to understand company programs and projects and accept his place on the team. Use of the terms "management" and "labor" should be avoided. Their use creates a mental barrier that has an unwholesome effect on accomplishing job objectives. Every member, though in varying degrees, is on the managerial team and it is hoped that everyone is laboring sufficiently hard to get his job done the way it should be. So, the supervisor should accept his responsibilities and co-operate with company programs and projects. He should be fair and equitable in his dealings with his employees. The company wants him to understand and respect the customers' problems, and assist them to the extent of his contacts and knowledge in the proper utilization of the company's service or product. These things, of course, should be done in an efficient manner, weighing costs involved in eliminating useless and needless expenditures and procedures.

Now, how about the customer? He has a right to expect of the supervisor the highest degree of performance possible. He feels that he is paying his good money for the service or product, and he wants and deserves the best. In addition though, he is looking to the supervisor as a source of information on matters affecting industry and his company in

particular. And, one of the most potent public relations appeals that one can have is the realization and acceptance that our companies are safe places to work. Conversely, a poor accident record tends to impair and injure the good will of our companies.

REQUIREMENTS FOR SUCCESSFUL SUPERVISORS

SOMEWHAT LOFTY STANDARDS are being set for supervisors by their employees, their company, and also their customers. What should supervisors be like to achieve the high degree of performance expected of them? Let us analyze this and see what some of the requirements are that go into making a successful supervisor.

1. He either should have, or do everything within his power to develop, a disposition, temperament, and personality that make friends for himself and his company, that inspire confidence from employees and customers alike. Some people are endowed by nature with more of these qualities than others, but anyone who considers himself shortchanged certainly can compensate for it if he has the right attitude and the desire to do so.

2. He should have the ability and willingness to accept responsibility: responsibility for the job being done, responsibility for the acts of his people. He must be willing to accept the responsibility for the job to be done.

3. He must have sufficient vision, and be enough of a team player to accept decisions and interpretations that are for the best interests of the company as a whole, but which may conflict in some small measure with his own personal interests, or with those of some member of his group.

4. He needs to have the ability and willingness to lead and not drive. His employees are looking for leadership, they need it, and feel that they are entitled to it.

5. He should have a desire to know and understand the members of his group and be of genuine help to them on the job. He should enjoy that confidence to such an extent that they will seek his counsel on other matters, but at the same time, he should not meddle in their personal affairs, nor uninvitedly offer advice. The supervisor who knows and understands his people, and assigns them work according to their abilities and handicaps, is a supervisor who has few accidents.

6. He should be able to evaluate the effect that decisions he may make in his group will have on other groups in the company. Within the authority allotted to supervisors, many decisions must be made. Occasionally though, decisions are made that are slightly out of the area or framework of their authority, yet at the time there seems justification for such decision and corresponding action. They should be weighed carefully to be sure that they will not spill over into other groups with a harmful result, or backfire later on the supervisor himself as an established precedent.

7. He should have the ability and willingness to compliment and encourage the members of his group when due. Criticism has been levelled at supervisors in many companies that they are too slow to offer just praise or commendation when it has been due and earned by outstanding performance.

8. He should have the courage to criticize his people when such criticism is due. However, it should be done tactfully, and only after very careful preparation. It should be done in a constructive manner, and at no time when in an angry frame of mind. The purpose of criticism is correction, and that never will be achieved if it is done in the wrong manner. Needless to say, any criticism of employees should be done in a confidential manner with no one else present. An accident is in the making when a supervisor improperly, and perhaps unjustly, criticizes a member of his group in front of others and then that employee goes on a hazardous job. He is resentful, bitter, and his thoughts are on the injustice done him, rather than focused entirely on the hazardous work to be done.

9. He should have the courage to say "No" when due. Seeking advice and counsel is a sign of wisdom, but passing the buck is a sign of weakness. A supervisor who approves any request that may come his way because he does not have the courage to say no, and passes the responsibility for such unpleasant decisions to higher supervision is not doing his job. Passing on the responsibility does not enhance the supervisor in the eyes of his employees. On the contrary, they look on him as a sort of middleman in the deal, who neither has the courage of his convictions, nor the authority to discuss matters requiring decisions. It takes courage sometimes to say no, but by so doing, the supervisor goes up in the esteem of the members of his group.

10. A supervisor should not make decisions without the benefit of all available influencing facts. He is called on to make many decisions in a day. Sometimes those decisions are made without the benefit of all the facts in the matter, and later in retrospect he realizes that if he had had more information, his decision perhaps would have been different.

11. A supervisor should be a good listener. There are many occasions when he can learn much more by keeping his mouth shut, and his ears open, than conversely. There are many times when all an employee wants and needs to emerge from a confused and unhappy state is a sympathetic listener. It is a trait that should be developed, if lacking.

12. It obviously goes without saying that a supervisor should have a working knowledge of the technical aspects of the jobs in his group. This is applicable whether the work to be done is in the engineering, construction, operating, sales, production, accounting, or some other phase of his company's operations. He cannot be a stranger to the work being done.

13. A supervisor should know what is going on in his group, and in his area. He should be able to evaluate such knowledge and pass it on to higher supervision when circumstances warrant it.

CONCLUSION

THE SUPERVISOR'S JOB is summarized briefly as follows:

1. Select people carefully.
2. Tell them the whole employment story.
3. Train them thoroughly.
4. Encourage and compliment them when deserved.
5. Criticize with care and caution—always in private—and never when angry.

6. Give them the leadership they are entitled to, need, and want.

7. Handle complaints or gripes promptly and thoroughly. If an employee is right, and it is within your authority to correct the condition that caused the complaint or gripe, do so. If it is not within your authority, or would adversely affect others, refer it to higher supervision.

8. Be a good listener. Make instructions clear and easily understood. If hazardous work is involved, have the employee repeat to you your instructions.

9. Analyze problems thoroughly, and use good judgment in reaching decisions.

10. Keep informed on matters affecting you, your group, your company, and your industry.

11. Do not play favorites.

12. Do not "pass the buck."

13. Do not talk unkindly about other supervisors or other employees.

14. Do not take action on controversial measures until you have all the available facts.

These supervisory responsibilities that have been discussed and enumerated are an integral and vital part of any accident prevention program. They offer a foundation on which to build a low accident experience and will offer an atmosphere of pleasant and harmonious relations.

In the Book of Exodus it is written: "And Moses chose able men out of all Israel, and made them heads over the people, rulers of thousands, rulers of hundreds, rulers of fifties, and rulers of tens. And they judged the people at all seasons; the hard causes they brought unto Moses, but every small matter they judged themselves."

The jobs of supervisors too are to make decisions and afford leadership—leadership that will redound to the interest of their employees, their company, and their customers, and in so doing eliminate those things that result in injuries to their people.

Investigation of Power Connectors for Use Outdoors With Aluminum Conductors

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R. W. HONEBRINK

The work that has been done on power connectors for outdoor use with aluminum conductors is described and conclusions presented pertinent to the design and use of tin-plated copper alloy or aluminum power connectors.

THE INCREASING emphasis upon aluminum as an electric conductor brings into sharp focus the problem of making satisfactory aluminum cable connections. The general factors involved in the use of aluminum as a conductor are

1. The electrolytic corrosion which occurs when dissimilar metals are brought into contact with aluminum, especially in the presence of moisture.
2. The high-resistance oxide film which develops rapidly on aluminum and which is extremely tenacious.
3. The softness, creep characteristics, and high thermal coefficient of expansion of aluminum.

Two specific problems peculiar to cable connections are the interstrand resistance of the cable, and the difficulty of preventing moisture and corrosive gases from affecting the contact surfaces.

An investigation has been conducted to determine what combination of material, metallic finish, joint compound, and technique would result in the most satisfactory connector for outdoor use with aluminum conductors. It deals with joints not subject to control by a manufacturer. Other papers[1,2] are available which describe the characteristics of joints for aluminum busses and connections in factory-assembled switchgear that are successfully using silver-plated contact surfaces.

OBJECTIVE

THE INVESTIGATION was initiated to evaluate the following principal factors as they affect connectors for aluminum cable:

1. The relative merits of serrated and smooth-contact surface designs.
2. The effect of high humidity, which tends to accelerate corrosion on various metallic finishes.
3. The value of various joint compounds with respect to corrosion protection and reduction of interstrand resistance.
4. The creep and expansion effects due to heat cycling.

Full text of paper 53-105, "An Investigation of the Performance of Power Connectors for Use Outdoors With Aluminum Conductors," recommended by the AIEE Committees on Substations and Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Not scheduled for publication in AIEE *Transactions*.

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TEST PROCEDURE

THE TEST SPECIMENS consisted of bolted-type cable connectors, see Figure 1, clamped to the ends of 15-inch lengths of 500,000-circular-mil electric-conductor grade aluminum cable. Before assembly the cable ends were cleaned with emery paper under oil to remove the oxide film. They were then rinsed in clean oil and drained but not wiped, so that an oil film adhered to the cable and prevented reformation of the oxide film during assembly of the joints. All clamping nuts were tightened to a uniform torque by means of a calibrated torque wrench.

In order to simulate outdoor exposure conditions, the tests were conducted in a humidity chamber, into which moisture was introduced by means of a heated siphon-fed water reservoir. All test specimens were connected in series and carried 600 amperes, 150 per cent of the cable rating, in 3-hour-on, 3-hour-off cycles. As a result of the current cycling the cable joint temperatures changed approximately 55 degrees centigrade between the on and off periods.

Thermocouples were attached to each test connector and millivolt leads were brought out from each joint so that joint temperature and joint resistance could be measured periodically. The exterior of the humidity chamber, with millivolt leads attached, and the automatic temperature-recording equipment are shown in Figure 2, while the interior of the humidity chamber and one of the specially constructed test racks are shown in Figure 3.

EVALUATION OF CONTACT SURFACE DESIGN

IN THE DESIGN of connectors for copper cable it has been found advantageous to provide fine circumferential serrations around the interior of the connector bore. By penetrating the cable surface and embedding themselves in the conductor, these serrations provide excellent metallic contact between cable and connector, and also increase the mechanical pull-out strength of the assembly. Since aluminum is characterized by more troublesome film formation than copper, it was felt that contact surface serration also might be beneficial for connectors for aluminum cable, and a test was set up to evaluate its effect. Serrated and smooth-bored connectors of cast aluminum with aluminum bolts were included. Four connectors of each type were tested with no joint compounds used.

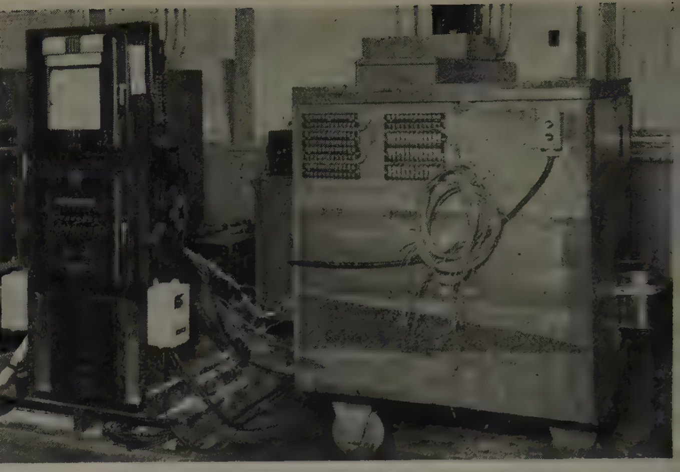


Figure 2. Exterior of testing equipment showing automatic recorder

Figure 1. Typical section of cable and connectors after test

Since it was the purpose of this test to compare the two types of contact surface, the strands at the ends of the cables were fused in order to eliminate the variable of interstrand resistance. The welding, of course, annealed the ends of the cables. For this type of test the joint resistance was measured between points *A* and *B* shown on Figure 4.

Table I. Results of 6 Months of Continuous Operation, or Approximately 680 Heat Cycles

Connector Material	Hardware (U Bolts)	Surface	Average Initial Resistance (Microhms)	Average Resistance Rise After 680 Heat Cycles (In Per Cent)
Aluminum	Aluminum	Serrated	3.3	0
Aluminum	Aluminum	Smooth	3.9	0
Zinc-plated copper alloy	Aluminum	Serrated	6.0	24
Zinc-plated copper alloy	Aluminum	Smooth	9.2	84
Zinc-plated copper alloy	Silicon-bronze	Serrated	7.1	25
Zinc-plated copper alloy	Silicon-bronze	Smooth	7.2	106

For all three combinations of connectors and hardware, the joints with serrated contact surfaces had a lower initial resistance than those with smooth contact surfaces. For the plated copper-alloy connectors with both types of hardware, the rate of resistance rise for the smooth-bore connectors was about four times that for the serrated connectors, while for the cast-aluminum connectors the joint resistance was quite constant throughout the test for both contact surfaces. These results indicate that the biting action of the contact serrations has the same ad-

vantages for use with aluminum cable that it has for copper cable. On the basis of these results terminals with serrated contact surfaces were selected for further test.

EVALUATION OF METALLIC FINISHES AND JOINT COMPOUNDS

For most aluminum cable applications the bore of the connector must clamp to aluminum while the terminal tang must be suitable for connection to the copper or silvered surface of the terminal pad of disconnecting switches or other apparatus.

In order to determine how these requirements can be met best, further tests were performed on connectors having various metallic finishes, with and without joint compounds. The ends of the cables for these tests were left unwelded so that the effect of individual strand corrosion on the over-all resistance would be included, as is the case in actual applications. The strands were fused at the center of the cable, however, so that the failure of one joint would not distort the current distribution in the joint at the opposite end of the cable.

The test specimens included the following metallic finishes on copper-alloy connectors with serrated contact surfaces:

1. Cadmium.
2. Zinc.
3. Tin.
4. Silver.
5. Nickel.
6. Aluminum-silver bimetallic insert.
7. Aluminum-copper bimetallic insert.

Cast-aluminum connectors with serrated contact surfaces also were included. A copper cable with silver-plated copper-alloy connectors also was tested to serve as a reference standard. Each of the foregoing finishes was tested without joint compound, and those which showed promise were tested with each of three commercial joint compounds:

Compound *A*—Soap-free grease (petrolatum base).
Compound *B*—Petrolatum base compound with zinc flakes.
Compound *C*—Active grease (oxide remover).

Figure 3. Interior of testing equipment showing arrangement of connections

Figure 4. Diagram showing where resistance was measured for cable with welded ends

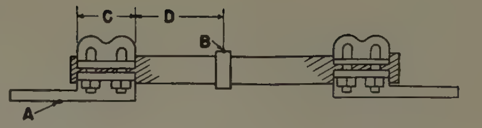
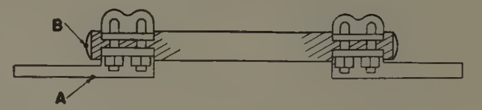


Figure 5. Same as Figure 4 for cable without welded ends



This series of tests also lasted for 6 months, or approximately 680 heat cycles.

The results of the tests without joint compound are shown in Figure 6. In these tests the resistance was measured between points *A* and *B* shown on Figure 5. The resistance of the free length of cable, *D*, was then subtracted to yield the joint resistance. The resistance ratio was obtained by dividing the joint resistance by the resistance of a piece of cable equal in length to the joint.

From the results of these tests, as shown in Figure 6, only the joints with cadmium- and tin-plated copper-alloy connectors and with cast-aluminum connectors performed satisfactorily and were comparable to the standard copper cable joint. All other joints showed rapid and accelerating increases in resistance and failed by excessive temperature rise. Connectors should perform well with or without joint compounds because the compounds may not be available when field connections are made. Cadmium is known to deteriorate in the presence of petroleum products or fatty acids, and since some compounds containing them may be used when applying connectors, it was felt that cadmium plating could not be considered as a satisfactory finish.

The connectors with various finishes which failed, shown by the chart in Figure 6, were eliminated from further tests. Tin-plated copper-alloy and cast-aluminum connectors were retested with three different joint compounds. The results are shown in Figures 7 and 8. In all cases the joints with compound were superior to those without, although the difference was not striking. Slight differences between compounds are apparent, compound *C* proving to be superior for both types of connector.

The resistance ratios of the connections with tin-plated copper-alloy connectors, Figure 7, are generally a trifle higher than those of cast-aluminum connectors, Figure 8. This is not due to the difference in joint resistance, but is because the conductivity of the cast-aluminum connector is slightly higher than that of the copper alloy. The difference is very small and is negligible for practical purposes.

Two samples of each type of joint were used in the foregoing tests and in every case the difference between identical joints was small compared to the differences between pairs of dissimilar joints. This is a good indication of the reliability of the tests.

GENERAL CONSIDERATIONS

Although the connectors tested are used for both cable and tubing, the investigation was restricted primarily to cable. This was felt to be the more severe

application because a tube does not have interstrand resistance, and will not distort as easily as a cable under clamping action. As a check a single aluminum tube with zinc-plated copper-alloy connectors was included in the second series of tests. These joints showed a considerably smaller increase in resistance than their cable counterparts, although their initial resistance was somewhat higher.

The chart, Figure 6, shows results with aluminum-silver and aluminum-copper bimetallic inserts. However, they

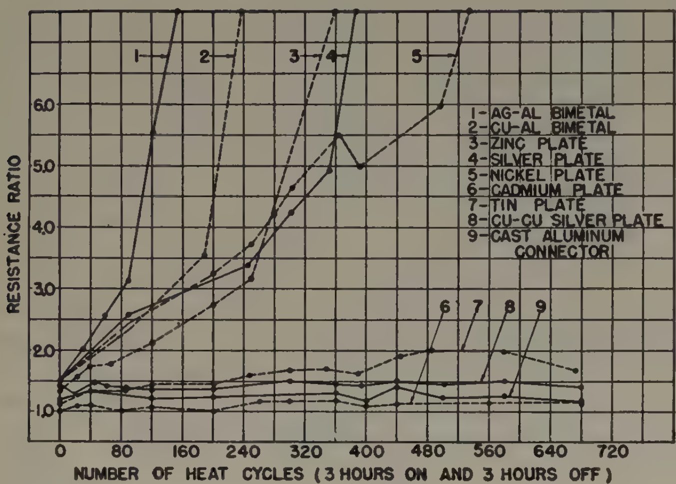


Figure 6. Resistance ratio of connectors with various platings, without joint compounds, and with serrated contact surfaces for 500,000-circular-mil aluminum cable

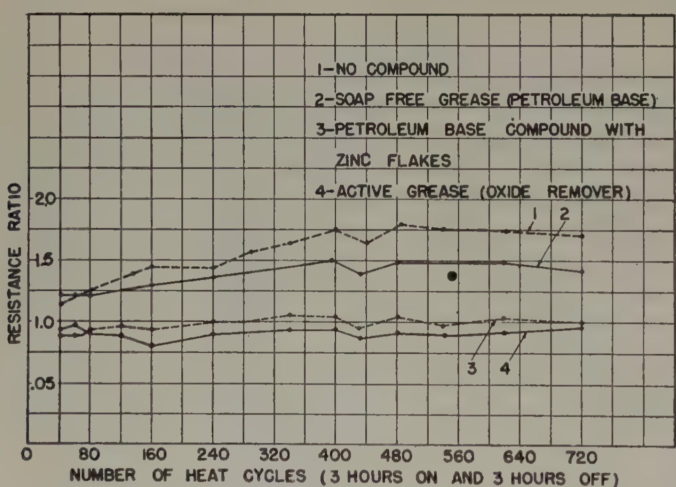


Figure 7. Resistance ratio of tin-plated copper-alloy conductors on aluminum cable with various joint compounds

are difficult to assemble properly in the joint. Because of this, it is doubtful that they would be acceptable for field use even if they had performed satisfactorily in test. The failure of the bimetallic inserts is probably caused, at least in part, by the introduction of another contact resistance in series and also a joint subject to additional galvanic corrosion.

There has been some question about the possibility of failure of cable joints when the material of the connecto bolts has a smaller coefficient of expansion than aluminum It is apparent that contact pressure is produced by th tightening of the bolts which fasten the top clamp and th bottom of the connector together around the cable. T avoid a loose contact joint caused by the expansion an contraction of aluminum cable due to heating and coolin the bolts should have essentially the same expansio characteristics as the aluminum conductor. In thes tests both silicon-bronze and aluminum bolts were teste with practically no difference in contact resistance. Th reason for this is that silicon bronze has a coefficient expansion of 9.5×10^{-6} inches per inch per degree temperature rise, as compared to 12.9×10^{-6} for *2S* alum num. The difference in expansion between the silico bronze bolts and the aluminum conductor 1 inch in diam eter would only be 1.7 millionth of an inch for 50 degre difference in temperature. This extremely small differenc would not affect the contact pressure sufficiently to caus any change in contact resistance. Steel hardware shoul not be used because of the greater difference in therma expansion of the steel and aluminum. Previous tes were made with zinc-plated copper-alloy castings havin steel hardware, and in all of these tests the terminals faile

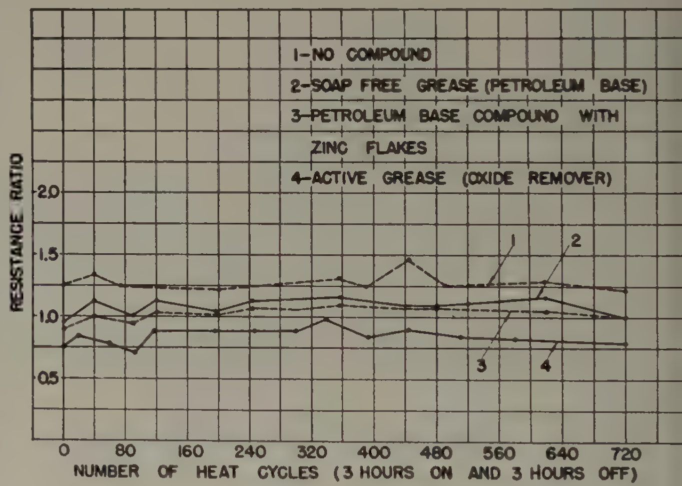


Figure 8. Resistance ratio of cast-aluminum connectors on alum num cable with various joint compounds

The failure was apparently due to the reduction in conta pressure resulting from the difference in expansion of ste and aluminum.

In the tests reported here it was found that the softne or hardness of the conductor did not greatly affect the co tact resistance. A bolt torque of 12.5 foot-pounds on soft conductor showed a lower resistance than that for th harder cable after more than 680 heat cycles. If co creep of the conductor would occur, it would appear affect the results of the tests on the soft cable more than f hard cable, but the tests showed the opposite result indicating that much larger torques would serve only distort the cable. The relaxation of contact pressure sometimes attributed to cold creep, but in many cases

may be caused by incorrect design of the connector. Either the contact area is too great, causing too low initial contact pressure, or too much bolt torque is used, causing creep of the bolt material which results in stretching of the bolt.

The test results show that both cast-aluminum and tin-plated copper-alloy connectors are satisfactory for connection to aluminum cable. As pointed out previously the tang of the connector also must be suitable for connection to copper- or silver-surfaced apparatus terminals. This means that the tang of the cast-aluminum connector must be modified to make it applicable for general use. Sometimes a thin copper strip is brazed or soldered to the underside of the connector tang. This method may decrease the over-all efficiency of the assembly because it adds another contact joint of doubtful conductivity. It also creates the problem of corrosion at the edges of the joint, with the possibility of galvanic action caused by moisture finally penetrating between the two metals at the joint and causing failure of the complete assembly. The tin-plated copper-alloy connector has the advantage of versatility over cast aluminum, since both its clamp and its tang may be connected to aluminum, copper, or silvered surfaces without further modification. For proper performance the tin plating on the copper-alloy connectors should be heated first and then "flowed" to assure complete coverage of the copper.

CONCLUSIONS

1. Both tin-plated copper-alloy connectors with silicon-bronze bolts and cast-aluminum connectors with aluminum bolts perform satisfactorily on aluminum cable, with or without joint compounds.

2. The use of a joint compound improves connector performance, with slight differences between compounds.

3. For the connector design and techniques used in these tests, the observed amounts of creep and cold flow due to differential expansion rates do not appear troublesome.

4. While cast-aluminum connectors are suitable for clamping to aluminum cable, the connector tang must be modified in some way to avoid corrosion when it is connected to the copper or silvered surfaces of apparatus terminals. Tin-plated copper-alloy connectors have the advantage of versatility in that either end of the connector may be applied to aluminum, copper, or silver-surfaced conductors. This versatility will reflect itself in the economic advantages of interchangeability of parts, reduction of inventories, and reduced procurement time because of standardization of components.

5. The results of the investigation may be strictly applied only to the connector design tested, under heat-cycling conditions in a humid atmosphere. Further investigation will be necessary to evaluate fully the effects of highly corrosive atmospheres, variation in contact surface size, and the use of single connectors to accommodate range of cable sizes.

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1. Application of Aluminum Channel Conductors for Station Bus, **E. J. Casey, N. Swerdlow.** AIEE *Transactions*, volume 71, part III, pages 1004–09.

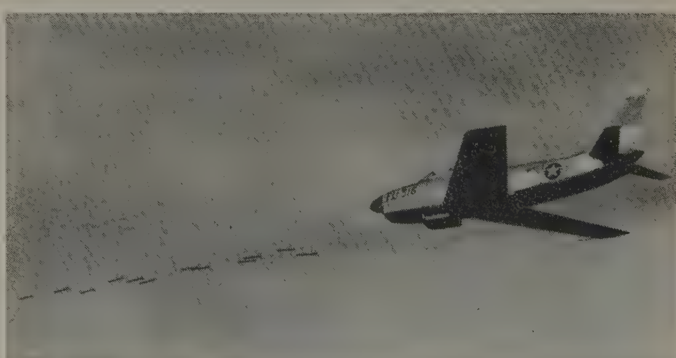
2. Performance of Electrical Joints Utilizing New Silver Coating on Aluminum Conductors, **T. J. Connor, W. R. Wilson.** AIEE *Miscellaneous Paper 53-104*, 1953.

Automatic Rocket-Firing Device for Jet Interceptors

The United States Air Force has revealed a secret rocket-firing device in the *F-86D* Sabre Jet interceptor which automatically unleashes rockets capable of shooting down the world's biggest bomber with a single volley. Designed as a high-altitude all-weather interceptor, the jet fighter can carry 24 Mighty Mouse 2.75-inch rockets in a retractable launching pod which pops out from the plane's fuselage. Immediately after firing, the pod snaps back into the airplane, giving it a streamlined surface for near sonic flight.

Helping the pilot hunt out and destroy an enemy bomber at night or in any kind of weather, the plane carries more electronic equipment than the average television station. The nation's only 1-man interceptor, the *F-86D* is considered an important part of this country's defense against a sneak air attack. With its powerful General Electric *J-47* engine and afterburner, it can take off and climb quickly to extreme altitudes.

Initially, the pilot will be guided to a target area by ground radar. Then powerful electronic beams from his own equipment will lock on the enemy plane. Electronic devices automatically compute range, speed, and probable course of the target. The pilot, who might never see his enemy except as a blip or smear on his radar scope, can fire all 24 rockets. A single hit from one of the rockets, which is roughly equivalent to a 75-millimeter artillery shell, can bring down the biggest bomber. The rockets streak toward their target at approximately 2,000 miles an hour.



First photograph of a secret rocket-firing device on the F-86D Sabre Jet has been released by the United States Air Force. Twenty-four rockets can be fired automatically from the launching pod which retracts into the plane's fuselage

Electronic Frequency Changer

HAROLD WINOGRAD
FELLOW AIEE

IN 1943, A 6,667-KW ELECTRONIC frequency changer, using mercury-arc rectifiers, was installed in the Gary Sheet and Tin Mill of the United States Steel Company, at Gary, Ind., to provide a nonsynchronous tie between the 25-cycle and 60-cycle power systems for the controlled flow of power in either direction. A nonsynchronous interconnection had to be used because ot the frequency variations on the 25-cycle system. In 1949 the capacity of the installation was increased to 16,000 kw by raising the capacity of the first unit to 8,000 kw and adding a second 8,000-kw unit. The installation has a 2-hour rating of 20,000 kw.

A power-circuit diagram of one unit is shown in Figure 1. It consists of two rectifier transformers and four 12-tube excitron rectifiers. The transformer a-c windings are connected to the power systems. Each 6-phase d-c winding and the rectifier to which it is connected constitute a rectifier group. On the d-c side the unit is divided into two sections, *A* and *B*, each consisting of a 60-cycle and a 25-cycle rectifier group with their d-c circuits connected in series. The d-c circuit, which operates at 1,750 volts is the link between the power systems.

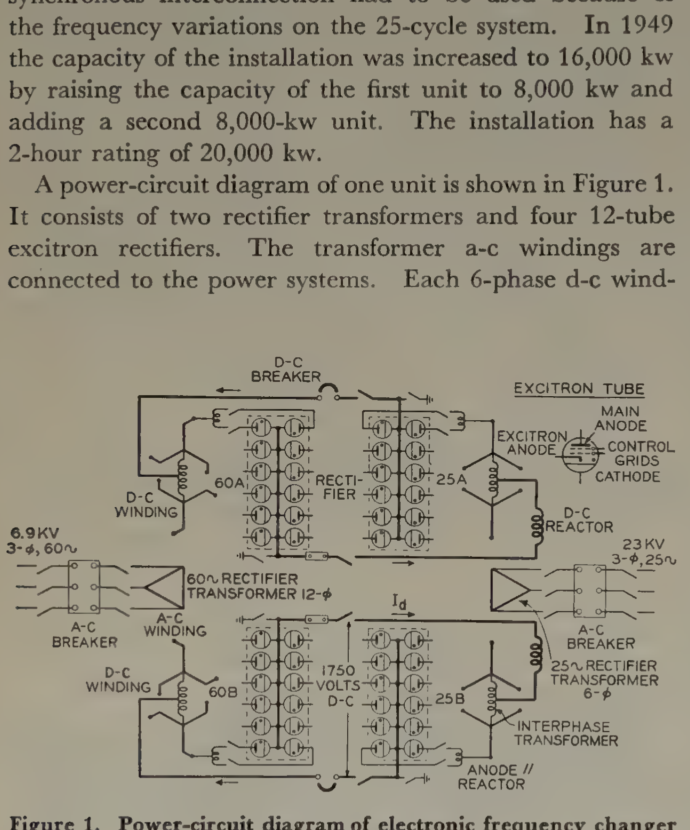


Figure 1. Power-circuit diagram of electronic frequency changer installed at Gary, Ind.

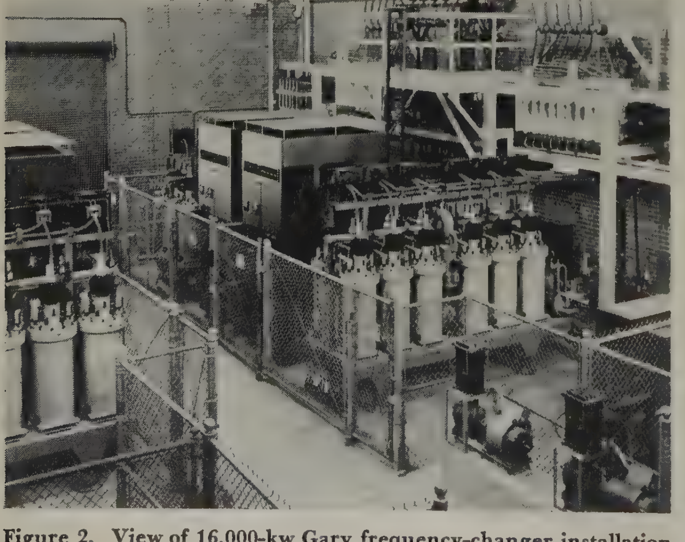


Figure 2. View of 16,000-kw Gary frequency-changer installation

To explain the operation of the frequency changer, it will be assumed that section *A* transmits power from the 60-cycle to the 25-cycle system. Power from the 60-cycle system is converted to d-c power by rectifier group *60A* operating as a power rectifier; the d-c power is converted then to a-c power into the 25-cycle system by group *25A* operating as a power inverter. The power flow can be reversed by reversing the functions of the groups. The power-conversion function of a rectifier group is reversed by reversing its direct voltage, which is effected by shifting the conducting period of the anodes from the positive half-cycles to the negative half-cycles of their phase voltages, or conversely. This is accomplished by grid control of the rectifier, without any change in the power circuit. The current can flow in one direction only through the rectifier.

The direct voltages of the power rectifier and the power inverter are in opposite directions in the d-c link, and the direct current is circulated by the voltage of the power rectifier against the inverter back-voltage, which is comparable to the back-electromotive-force of a d-c motor. The transmitted power is proportional to the current in the d-c link and is regulated by phase control (grid control) of the power-rectifier voltage. The power is maintained at a preset adjustable level by a regulator.

A view of unit 2 of the Gary frequency-changer installation is shown in Figure 2. The 25-cycle equipment is at the right of the aisle, the 60-cycle equipment at the left. The excitron tubes of each rectifier are mounted on a base which is supported on insulators. The control cubicle adjacent to the rectifier contains the excitation and grid control equipments and other rectifier control accessories. Each rectifier is cooled by a recirculating water cooling system with a water-to-water heat exchanger. The d-c circuit breakers are mounted on balconies. The rectifier transformers, d-c reactors, and a-c circuit breakers are located outdoors.

The operating and power regulating controls of each unit are mounted on a switchboard, at the opposite end of the station. The direction of power flow is set by a selector switch. Control switches are provided for starting and stopping the unit. The transmitted power level is controlled either by a maximum-demand meter or by hand rheostats, depending on the position of a selector switch.

Digest of paper 53-53, "Electronic Frequency Changer Used as Nonsynchronous T[ie] Between A-C Systems," recommended by the AIEE Committee on Electronic Pow[er] Converters and approved by the AIEE Technical Operations Committee for present[a]tion at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 195[3]. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

Harold Winograd is with Allis-Chalmers Manufacturing Company, Milwaukee, Wi[s].

Outstanding Young Electrical Engineers—1936-1951

V. L. DZWONCZYK
MEMBER AIEE

Each year, Eta Kappa Nu honors outstanding young electrical engineers for meritorious service to their fellow men. This analysis of the backgrounds of the 259 candidates from 1936 to 1951 may help future aspirants to these awards in planning their own careers.

THE Recognition of Outstanding Young Electrical Engineers award, offered annually by the honorary electrical engineering society, Eta Kappa Nu (HKN) was conceived simultaneously by E. B. Wheeler and R. I. Wilkinson[1] in the early thirties. It was so well developed and guided by Mr. Wilkinson that its acceptance as an honor for which young men should strive is gaining steadily. The award is given for "meritorious service in the interest of their fellow men." Its purpose is "to emphasize among electrical engineers that service to mankind is manifested not only by achievements in purely technical pursuits but by a variety of other ways."

The award aims to inspire and guide young men in their early professional careers when the course seems so boundless, rough, and uncharted that a little incentive and praise is welcome. Biographical sketches published in the *Bridge of Eta Kappa Nu* and the annual award dinner provide media for praise and inspiration; and they focus attention upon the extraordinary accomplishments that energetic young men do achieve when given the education, incentive, and opportunity.

This award was carefully planned for young electrical engineers of good character, not older than 35 years, and who have been graduated not more than 10 years from a recognized American school.

AWARD ADMINISTRATION

FINAL SELECTIONS of a winner and honorable mentions are made by a jury which is annually appointed by the president of HKN and composed of two present or past national HKN officers, and three or more prominent American educators or industrialists who need not be members of the society. Past juries have had the generous services of many distinguished men, among them Vannevar Bush, O. W. Eshbach, E. L. Moreland, R. W. Sorenson, and Philip Sporn.

The Award Organization Committee canvasses the country for nominees, scrutinizes their records, assists the jury, and plans the Award Dinner. Candidates' records are first studied by the committee, confidential ratings are established, and then the records of approximately the top third are submitted to the jury for comprehensive review. However, all candidates' records are available to the jury. Before final selections are made, the jury's and the committee's ratings are compared and, if a major discrepancy appears, the situation is discussed fully. The committee and juries have deemed it advisable to make this comparison because of their mutual desire to obtain the most accurate selections. At all times, however, the jury's decision is final.

It is often asked, "What kind of information does the jury review?" The candidate's dosier consists of a personally answered 6-page questionnaire[1] together with the nominator's story and letters submitted by as many as ten references.

From 1936 through 1951, 274 men were nominated of whom 11 declined the nomination and 4 were disqualified. The remaining 259 candidates and their references submitted data which stack approximately 5.5 feet high and weigh 149 pounds. These records have been carefully analyzed and the data presented in this article represent the more interesting facts contained in them. Table I lists the names of 16 winners and 39 honorable mentions who gained recognition from 1936 to 1951.* Only one

* In 1952 J. V. N. Granger was Outstanding Young Electrical Engineer and E. O. Johnson and G. W. Staats received honorable mentions.

Table I. HKN Recognition Awards: 1936–1951

Year	Winner	Year	Winner
1936:	F. M. Starr	1944:	Dr. R. W. Porter
1937:	Dr. C. G. Suits	1945:	J. M. Wallace
1938:	Dr. W. E. Kock	1946:	Dr. E. M. Williams
1939:	L. A. Meacham	1947:	R. R. Hough
1940:	Dr. J. E. Hobson	1948:	Dr. A. M. Zarem
1941:	Dr. Cledo Brunetti	1949:	R. C. Cheek
1942:	Dr. J. R. Pierce	1950:	Dr. D. P. Campbell
1943:	N. I. Hall	1951:	L. G. Gitzendanner

Honorable Mentions

Year	Honorable Mentions	Year	Honorable Mentions
1936:	P. L. Bellaschi E. W. Boehne Dr. A. C. Seletzky G. Veinott	1944:	W. E. Ingerson Dr. E. H. Krause D. W. Pugsley
1937:	L. L. Carter P. T. Farnsworth C. A. Faust	1945:	W. A. Depp Dr. J. A. Morton E. A. Post
1938:	H. E. Gove Dr. G. M. L. Sommerman	1946:	B. B. Bauer Dr. A. C. Hall Dr. D. A. Waidlich
1939:	C. K. Gieringer J. E. Hobson	1947:	M. Camras J. B. Wiesner
1940:	D. G. Fink S. C. Hight	1948:	J. W. Forrester M. E. Mohr
1941:	Dr. Simon Ramo G. F. Leydorf	1949:	Dr. L. M. Field L. G. Gitzendanner
1942:	Dr. G. D. McCann D. B. Smith	1950:	A. W. Edwards K. A. Kesselring R. W. Mayer
1943:	A. G. Kandoian Dr. J. W. McRae	1951:	B. R. Lester R. L. Trent

Full text of a special article recommended for publication by the AIEE Committee on Education.

V. L. Dzwonczyk, Operating Sponsor, American Gas and Electric Service Corporation, New York, N. Y., is a member and past chairman of the Eta Kappa Nu Award Organization Committee.

Table II. Schools Which Candidates Attended

School	Degrees Granted to Candidates: Total	B.S.	M.S.	Ph.D.
Alabama Polytechnic Inst.	2	2		
California Inst. of Tech.	27	6	9	12
California, Univ. of	4	2	2	
Carnegie Inst. of Tech.	6	6		
Case Inst. of Tech.	3	2	1	
Catholic University	3	2	1	
Cincinnati, Univ. of	10	7	3	
City College of N. Y.	3	2	1	
Clarkson Inst. of Tech.	1	1		
Colorado	2	2		
Columbia	11	4	6	1
Cooper Union	1	1		
Cornell	8	7		1
Duke	2	2		
Florida	3	2	1	
Georgia Inst. of Tech.	6	5	1	
Gettysburg	1	1		
Hardin Simmons	1	1		
Harvard	17	3	9	5
Idaho	1	1		
Illinois Inst. of Tech.	8	6	2	
Illinois, Univ. of	7	6	1	
Iowa State	9	5	2	2
Iowa, Univ. of	4	2	2	
Johns Hopkins	15	6	5	4
Kansas State	8	7	1	
Kansas, Univ. of	5	4	1	
Kentucky	3	3		
LaSalle	1			1
Lehigh	12	9	3	
Maine	4	2	2	
Marshall, John	1			1
Maryland	4	2	1	1
Mass. Inst. of Tech.	48	19	24	5
Michigan State	3	2	1	
Michigan, Univ. of	13	6	5	2
Milwaukee	1	1		
Minnesota	8	4	3	1
Missouri	5	4	1	
Nebraska	4	4		
Newark	1	1		
North Carolina State	1	1		
North Dakota	2	2		
New Hampshire	1	1		
New York University	1	1		
Notre Dame	1	1		
Northeastern	1	1		
Northwestern	5	3	1	1
Ohio State	10	5	5	
Oregon State	6	4	2	
Pennsylvania State	4	4		
Pennsylvania, Univ. of	16	6	7	3
Pittsburgh	12	2	9	1
Polytechnic Inst. of Bklyn.	5	4	1	
Princeton	5	3	1	1
Purdue	20	13	6	1
Rennselaer Inst.	2	2		
Rice	4	4		
Rochester	1		1	
Rutgers	5	4	1	
Stanford	7	3	2	2
Stevens Inst. of Tech.	2		2	
South Carolina	1	1		
Texas A & M	13	10	2	1
Texas Inst. of Tech.	2	2		
Texas, Univ. of	3	2	1	
Tufts	1	1		
Union	3	1	2	
Utah	2	2		
Vermont	1	1		
Virginia Military Inst.	2	2		
Virginia Polytech. Inst.	1	1		
Washington (Missouri)	4	2	2	
Washington, Univ. of	3	3		
Washington State	1	1		
Wayne	1	1		
Western State Teachers	1	1		
West Virginia Univ.	2	1	1	
Wisconsin	10	4	3	3
Worcester Polytech.	1	1		
Yale	8	2	3	3
Foreign Universities				
Alberta, Univ. of	2	1	1	
Berlin, Univ. of	1			1
British Columbia, Univ. of	1	1		
Cambridge	1		1	
National Tsinghum	1	1		
Zurich	2		1	1
No college degree	1			
		258	143	54

candidate did not go to college but his accomplishments gained him an honorable mention. The candidates' average age when nominated was 31 years and an average of 8.5 years had elapsed between baccalaureate degree and nomination date.

Each year at the Award Dinner, which is held during the AIEE Winter General Meeting, the outstanding young electrical engineer and honorable mentions are honored publicly. Often heard at these dinners are such inquiries as: What supplemental educational training seems advisable in addition to a basic electrical engineering degree? How is the candidate influenced by ordinary family responsibilities—a wife, home, and children? Does he accomplish this objective purely because of his success on the job? In what civic activities does he volunteer his time? Must he participate in cultural pursuits as well? What other extraordinary achievements seem desirable?

These questions are partially answerable by the following ratings and considerations given by past juries:

(*a*). Chosen work .... 50 points
(*b*). Community, state, and national activities .... 20 points
(*c*). Cultural and aesthetic development .... 10 points
(*d*). Hobbies and other accomplishments .... 20 points

A comprehensive analysis of the 259 candidates' records should shed further light on these considerations. It may help future award aspirants to plan their careers early and more broadly. This review even might supply additional facts which will assist those studying the needs of th engineering profession—the attraction of new students the enhancement of the professional engineer's standing

BACKGROUND OF THE CANDIDATES

Education. Table II lists schools from which candidate obtained baccalaureate, master, and doctorate degrees and it indicates a remarkable country-wide distributio of institutions of higher learning. The records reveal tha 16 large and small universities, in the east, west, south and north, share the honor of educating winning candidate in undergraduate studies. Graduate studies were under taken at California Institute of Technology by three win ning candidates; at Yale University by two; and Tech nische Hochschule, Zurich, Switzerland, the University c Berlin, Germany, the University of Minnesota, and th Massachusetts Institute of Technology each conferre doctorates on one winner. The 39 honorable mention were educated in 23 different schools; and one did no graduate from college. Some doctorate degrees wer granted this group also; four by California Institute c Technology, two by Johns Hopkins University, and on each by Columbia University, State University of Iowa Massachusetts Institute of Technology, and University c Wisconsin.

With this in mind, we may ask, "Is there a logica

relation between postgraduate education and the success of nominees?" Table III contains some interesting facts in this respect.

These data indicate that the successful candidates pursued higher education in greater percentage numbers than others. Of the 12 winning men having postgraduate education, ten, or 83 per cent, did so before employment in their chosen field. One of the winners holding a master's degree obtained it after working hours. The other winner obtained his doctorate while teaching at the university in which he was employed when the award was earned. It is noted that 28 of the 39 honorable mentions had advanced degrees. Eight, or 28 per cent, of them obtained their doctorates, and 20, or 69 per cent, of them obtained a master's degree or the equivalent thereof, before starting to work. Other postgraduate degrees, namely, three doctorates and eight masters, were obtained by the men during evening sessions or while teaching.

Family Status. Considering that it takes considerable time to participate in the diversified activities upon which these men are judged, it becomes essential that the candidate's family status is not overlooked. It would seem to be a foolhardy accomplishment, for instance, if the man concerned were exceptionally active professionally, in civic and cultural affairs and with hobbies, if at the same time he neglected to cultivate close personal relations with members of his family. The nominees' family obligations are shown in Table IV.

Employment. A question often asked about a successful man is, "Did he work for one company or did he shift around before finding his niche?" Table V shows how the candidates' employment experiences varied among the groups.

Industries and Fields. The distribution of industries in which the candidates worked is shown in Table VI. Among other facts, it reveals that winners work in such industries as will afford young men an opportunity for research and development of new products. Contrary to popular opinion, there has been no preponderance of candidates in electronics work nor did this field monopolize the winners and honorable mentions. Table VII shows that General Electric Company, Westinghouse Electric Corporation, and Bell Telephone Laboratories have nominated large numbers of candidates, and their nominees gained many of the citations. It would appear, therefore, that these companies provide young college graduates early opportunities for self-expression.

Table VIII lists the candidates' fields of work. The 60-cycle and higher frequency fields have had their share of candidates and winners. The equipment manufacturers were mostly responsible for maintaining the power group in balance with others. In the winning candidates' group, research and development occupied the greatest number of men—13 out of 16, or 81 per cent.

Teaching Experience. One very significant observation seems to be that all men in the winning group were teachers. Some of them taught only at universities as instructors or professors, others taught mostly in industrial advanced engineering training programs, while some of them did

Table III. Candidates With Postgraduate Degrees

Number and Per Cent of Group Who Obtained		Degree: Masters	Degree: Doctors
Number:	Nonwinners (204)	103	34
	Honorable mentions (39)	28	11
	Winners (16)	12	9
Per cent:	Nonwinners	51	17
	Honorable mentions	72	28
	Winners	75	56

Table IV. Family Obligations

Number and Per Cent of Group Who		Were Married: Yes	Were Married: Average Years	Became Parents: Yes	Became Parents: Average No. Children	Owned Home
Number:	Nonwinners (204)	155	3.6	128	1.6	81
	Honorable mentions (39)	33	3.8	26	1.9	19
	Winners (16)	13	3.5	10	2.0	10
Per cent:	Nonwinners	76		63		40
	Honorable mentions	85		68		49
	Winners	81		63		63

Table V. Number of Employers

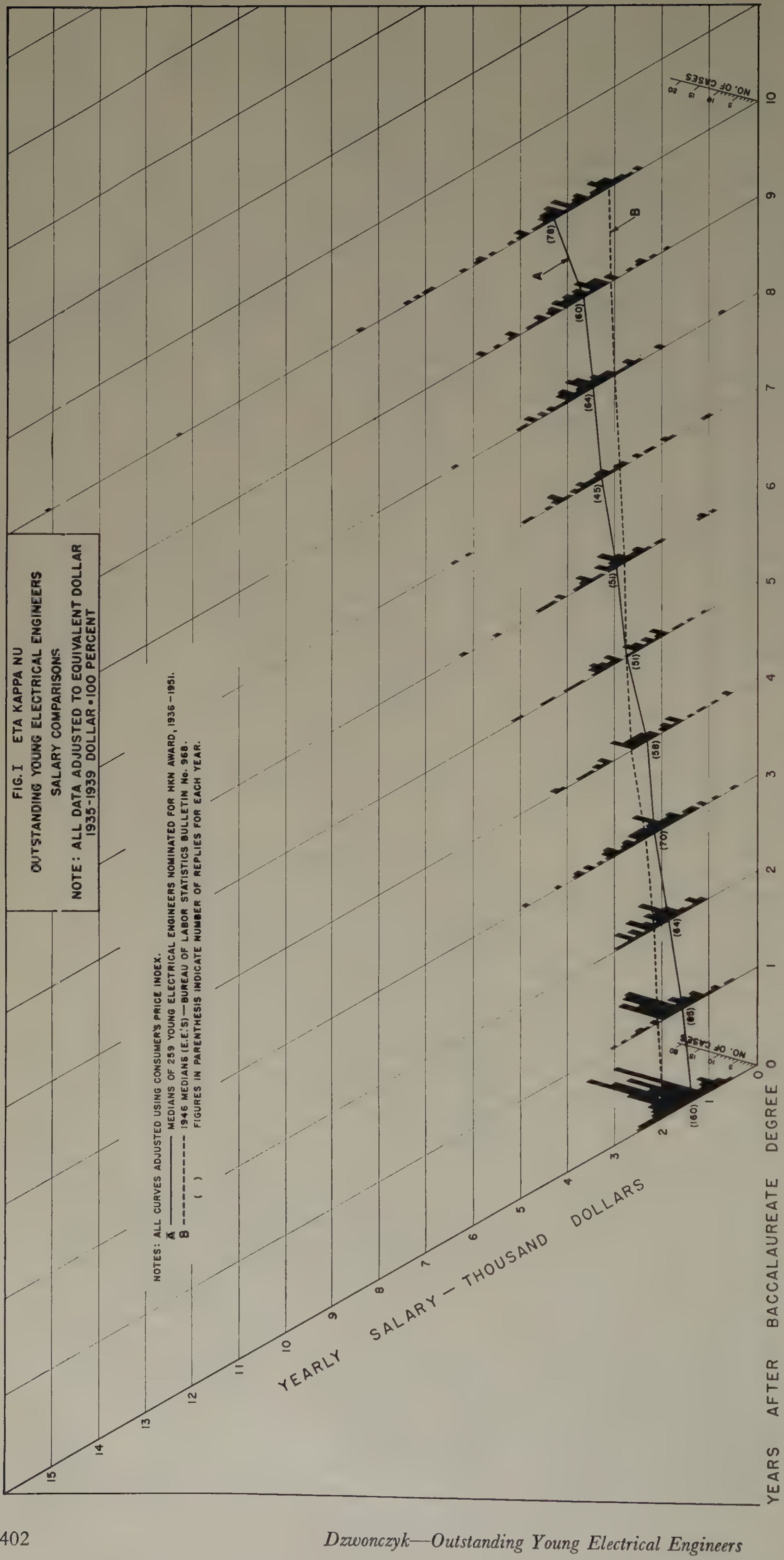
Number and Per Cent of Group Who Worked for		1	2	3	4	5	6	7	Median
Number:	Nonwinners (204)	108	36	35	19	5		1	1.9
	Honorable mentions (39)	22	7	8	1	1			1.8
	Winners (16)	9	1	2	2	1	1		2.2
Per cent:	Nonwinners	53	18	17	9	2		1	
	Honorable mentions	56	18	21	2.5	2.5			
	Winners	56	6	13	13	6	6		

Table VI. Distribution of Candidates in Industry

Industry Employing Candidate	Nonwinners	Honorable Mentions	Winners	Total
Electronics:				
Broadcasting	16			16
Telephony and telegraphy	16	7	4	27
Equipment manufacturers	34	7	1	42
Government	5	2	1	8
Universities	10	5	1	16
Candidate's business venture	2			2
Aviation	2	1		3
Other Than Electronics:				
Broadcasting	3			3
Telephony and telegraphy	17			17
Equipment manufacturers	67	13	7	87
Electric power utilities and consultants	6	1		7
Government	8			8
Universities	10	3	2	15
Candidate's business venture	4			4
Aviation	4			4
Total	204	39	16	259

Table VII. Distribution by Major Employers

Company	Nonwinners	Honorable Mentions	Winners	Total
Allis-Chalmers Manufacturing Company	4			4
Radio Corporation of America	11			11
United States Government	15	2	1	18
Universities	20	8	3	31
Westinghouse Electric Corporation	23	5	3	31
Bell Telephone Laboratories	24	7	4	35
General Electric Company	37	6	4	47
All others	70	11	1	82
Total	204	39	16	259



both. Among the honorable mention group, 34 out of 39 men taught; and 138 out of 204 nonwinning candidates did some teaching.

Writing and Patents. The 16 winners averaged 12 technical papers. Several men contributed to scientific fiction magazines; one wrote 17 amazing stories. The honorable mention group averaged eight papers, and one man who was engaged in editorial work claimed 3,250 semitechnical articles. The nonwinners averaged three technical papers.

These men's research and development achievements led to many patents; winners averaged eight, honorable mentions averaged four, and the others two. Two winners did not receive patents, but one man obtained 40

Salaries. Natural curiosity makes one wonder if the compensation received by men of this caliber is commensurate with their creativeness and productivity—monetary compensation, not psychic. Figure 1 illustrates the candidates' salary distribution and compares it to electrical engineers' median salaries reported in 1946 by Bureau of Labor, Bulletin *968.* Figure 2 gives median salaries of selected individual groups. All data have been adjusted to the 1935–39 dollar. The salaries only include compensation from the principal employer.

These men represent the most accomplished young electrical engineers in our country. Do their salaries provide adequate reward for the caliber of work performed? Can the salaries be regarded inspiring incentive to draw better men into the profession, or does this situation partly explain why students seek other fields where their education and abilities will realize greater appreciation

Civic and Cultural. We have re-
viewed that part of the candidate's record for which the jury assigns 50 points maximum. It is important to note that, except for those cited, the candidates' deficiencies lie mostly in civic, cultural, and other endeavors. However, the winners' records clearly emphasize that not all engineers are self-centered as some writers indicate. Tables IX and X show how candidates devoted their energies in the interest of their fellow men. How better could one seek relaxation than by cultivating a hobby or acquiring musical or artistic skill? Are not those who find time for such cultural and public spirited achievements richer, and the more deserving of riches?

The candidates participated also in such endeavors as are listed in Tables XI and XII. They were members of many honor organizations, for example, Tau Beta Pi, Sigma Xi, Phi Beta Kappa, HKN, and Pi Mu Epsilon.

These men were prolific readers. Their literary explorations included history, philosophy, religion, political science, economics, biography, classics, pure science, astronomy, and fiction. Space would not permit a listing of the many notable books that they have read, although a partial list has been published in the *Bridge of Eta Kappa Nu.*[8]

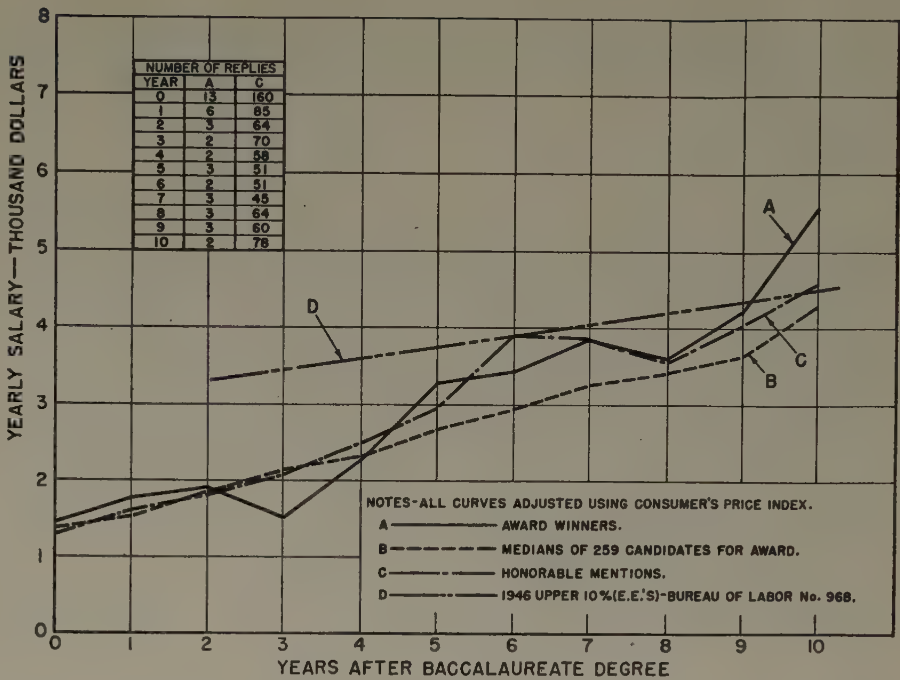


Figure 2. Salary comparisons of Eta Kappa Nu Outstanding Young Electrical Engineers candidates

All data adjusted to equivalent dollar: 1935–1939 dollar = 100 per cent

CONCLUSIONS

THIS IS THE amazing story of 259 young American men who saw the opportunity made possible for them in our great country; and who upon seeing this opportunity, followed a course of conscientious preparation and progressive accomplishment. Sixteen winners and 39 honorable mentions have reached not a goal, but an inspirational award that should spur them on to new and even greater achievements and honors.

What has been learned from these outstanding records of accomplishment which so clearly forecast appreciable future success to at least the 55 young men whom Eta Kappa Nu is pleased to honor? It would appear that the following observations stand well towards the top of any list that endeavors to describe the successful candidates' character:

1. Each man possessed a large capacity for and a genuine willingness to do hard work.
2. Each man valued and obtained a well-rounded education which was pursued continuously beyond the baccalaureate degree.
3. Each man developed the ability to think straight and long on problems that confronted him.
4. These men did not have any trouble discovering work and problems which held their interest intensely.
5. These men formulated and followed working and living habits that were conducive to an efficient use of their time.
6. Selfishness was not one of their recognizable faults, for they all contributed generously to activities benefiting mankind in civic, religious, or social fields.
7. They were all spurred on by greater incentives than monetary compensation—their psychic income must have been inspirational.

Table VIII. Distribution of Candidates by Fields of Work

Field of Work	Number of Candidates: Non-winners	Honorable Mentions	Winners	Total
Electronics:				
Audio	3	2	1	6
Radio	17	2		19
Television	10	3		13
Radar	5		1	6
Microwave	10	2		12
Tubes	9	2	1	12
Antennas	4	1	1	6
Computers	3	1		4
Telephony and telegraphy	4	4	1	9
Teaching	2	2		4
General	18	3	2	23
Subtotal	85	22	7	114
Other Than Electronics:				
High voltage	5	2		7
Insulation	4	2		6
Instruments	9	1		10
Protective devices and controls	10	1	1	12
Rotating machines	26	2	2	30
Stationary machines	5			5
Power system engineering	10	3	3	16
Telephony and telegraphy	10			10
Servomechanisms	2	3	1	6
Teaching	11	1		12
General	27	2	2	31
Subtotal	119	17	9	145
Grand total	204	39	16	259

8. These men had a faculty for being co-operative and instilling in others, especially their families, the value of co-operation; for it cannot be visualized how so much could be accomplished through the efforts of one man working by himself.

9. These men gave serious attention to the fostering of broad interests.

Those nominees who did not achieve quite enough to be among the winning group need not feel chagrined by the outcome. Some of them made significant records, just slightly less formidable than the winners. By and large the unsuccessful candidates rated well in professional attainments but they were decisively outclassed, except for a few instances, in civic, cultural, and other accomplishments.

While considerable effort has been made to obtain all known outstanding nominees for this award, it is recognized that some good candidates may have been overlooked. Eta Kappa Nu appeals to all members of our great profession to help assure that each year all of the country's outstanding young electrical engineers are given an oppo tunity to have their record of achievement reviewed by th jury.

It is hoped that these observations from the files Eta Kappa Nu's Recognition of Outstanding Your Electrical Engineers have been interesting. If they w inspire other young men to follow or better these exampl it was worth the effort. A teacher once wrote tha "There are two forms of poverty—the lack of goods for th higher wants and the lack of wants for the higher goods It would be a great misfortune if engineers should fail volunteer something of themselves to other activities tha their business or pleasure. Surely, these Outstandin Young Electrical Engineers have used their abiliti efficiently and generously.

Table IX. Activities in Behalf of Community, State, and Nation

Typical Activities	Participation of Candidates: Number of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)	Per Cent of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)
Church Affairs:						
Young peoples' or couples' groups	34	7	5	17	18	31
Directing, teaching, singing in choir	19	4	4	9	10	25
Member of operating committees	24	4	4	12	10	25
Teaching Sunday School	22	8	3	11	21	19
Maintaining equipment voluntarily	5		2	2		13
Organist in church voluntarily	2		1	1		6
Member of Board	24	6	1	12	15	6
Civic Affairs:						
Boy Scout work	23	6	4	11	15	25
Philanthropic collection drives	35	14	4	17	36	25
YMCA Youth and other youth work	7	8	6	3	21	37
Adult education	42	18	7	21	46	44
Civic Committee work	21	16	6	10	41	37
Miscellaneous:						
Boys' athletic and recreation activities	9		2	4		13
Local political activities	6	1	6	3	3	37
Aiding students through schools			3			19
Volunteer civil defense	4	2	2	2	5	13
Relief and welfare work	8		1	4		6
Rebuilding toys for underpriv. children	3		1	1		6
Parent-Teachers Association	5	2		2	5	

Table X. Cultural and Aesthetic Development

Typical Cultural Activities	Participation of Candidates: Number of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)	Per Cent of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)
Studied music and apprec. of music	18	6	7	9	15	44
Studied and plays instrument	45	12	10	22	31	63
Studied voice and sings in choral groups	7	5	2	3	13	13
Wrote articles on music and cultural subjects		2	6		5	37
Performs in amateur dramatics and minstrel shows	8	4	5	4	10	31
Paints in oils and water colors	8	3	5	4	8	31
Miscellaneous: (5 different fields)	5			2		
(7 different fields)		10			26	
(3 different fields)			5			31

Table XI. Hobbies and Other Accomplishments

Typical Activities	Participation of Candidates: Number of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)	Per Cent of Grou[p]: Non-winners (204)	Hon. Mentions (39)	Wi[n]ne[rs] (16)
Photography (stills, color, movies)	76	15	7	37	39	44
Amateur radio	29	5	4	14	13	25
Woodworking, furn. repair, tinkering	28	1	3	14	3	19
Gardening	37	6	4	18	15	25
Golf	30	3	1	15	8	6
Tennis	28	8	5	14	21	31
Swimming	15	9	1	7	23	6
Boating	10	5	1	5	13	6
Flying	4	1	2	2	3	13
Other sports	16	22	8	8	57	50
Stamp collecting	5	3		2	8	
Model building	3			1		
Astronomy, building telescopes	3	4	1	1	10	6
Miscellaneous (10 different interests)	16	5	1	8	13	6

Table XII. Membership in Honor, Scientific, and Profession Societies

Societies	Participation of Candidates: Number of Group: Non-winners (204)	Hon. Mentions (39)	Winners (16)	Per Cent of Grou[p]: Non-winners (204)	Hon. Mentions (39)	Wi[n]ne[rs] (16)
Tau Beta Pi (honorary engineering)	94	20	12	46	51	75
Sigma Xi (honorary science)	75	21	12	37	54	75
Eta Kappa Nu (honorary elec. engg.)	70	17	9	34	44	56
Phi Beta Kappa (honorary academic)	12	2	3	6	5	19
Scabbard and Blade (honorary ROTC)	10		3	5		19
Pi Mu Epsilon (honorary math)	18	4	1	9	10	6
Phi Kappa Phi (honorary scholastic)	29	6	1	14	15	6
Miscellaneous other honorary societies	62	12	6	30	31	37
AIEE	103	24	6	51	62	37
Institute of Radio Engineers	77	23	7	38	59	44
American Physical Society	10	4	3	5	10	19
American Society for Engg. Educ.	3	1	2	1	3	13
Professional engineers	10	2	4	5	5	25
Miscellaneous engg. and scientific soc.	36	14	10	18	36	63

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Coulomb Friction in Feedback Control Systems

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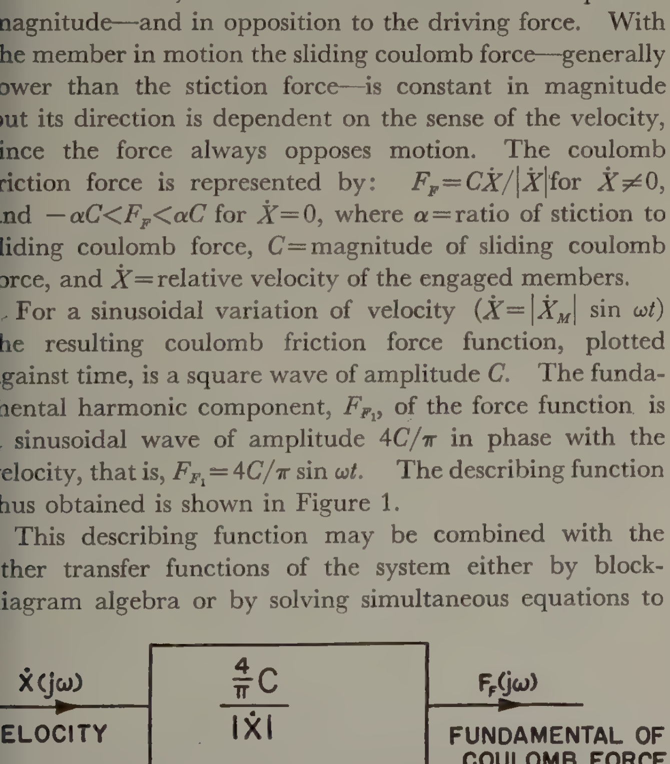
THE PRESENCE OF COULOMB (or "rubbing") friction in feedback control systems often results in ndesirable effects, such as an operating dead-zone, lowrequency wander, and poor dynamic performance for lowevel signals. In some systems, however, coulomb friction nay have a stabilizing effect. This article describes a nethod of predicting the effect of coulomb friction on static nd dynamic performance. Methods of introducing comensation are discussed for systems in which coulomb riction has an undesirable effect.

The relation between the output and the input of a inear component for a sinusoidally varying input can be xpressed as a function of the frequency of the input signal. f a sinusoidal signal is applied to a nonlinear element the utput will not be a sinusoid. In order to apply the same echniques used in linear systems only the fundamental armonic component of the nonsinusoidal output signal is onsidered; this component can be evaluated by Fourier nalysis or by actual measurement. The relation between he output and input of a nonlinear component then can e expressed as a function of the amplitude and frequency f the input signal. This relationship is called the decribing function.[1] A describing function representing he effects of coulomb friction is derived in this article.

The effect of coulomb friction is observed as a force pposing motion of a controlled member. With the nember at rest, the stiction coulomb force is equal in nagnitude—and in opposition to the driving force. With he member in motion the sliding coulomb force—generally ower than the stiction force—is constant in magnitude ut its direction is dependent on the sense of the velocity, ince the force always opposes motion. The coulomb riction force is represented by: $F_F=C\dot{X}/|\dot{X}|$ for $\dot{X}\neq 0$, nd $-\alpha C<F_F<\alpha C$ for $\dot{X}=0$, where α=ratio of stiction to liding coulomb force, C=magnitude of sliding coulomb orce, and $\dot{X}$=relative velocity of the engaged members.

For a sinusoidal variation of velocity ($\dot{X}=|\dot{X}_M|\sin\omega t$) he resulting coulomb friction force function, plotted gainst time, is a square wave of amplitude C. The fundanental harmonic component, F_{F_1}, of the force function is sinusoidal wave of amplitude $4C/\pi$ in phase with the elocity, that is, $F_{F_1}=4C/\pi \sin\omega t$. The describing function hus obtained is shown in Figure 1.

This describing function may be combined with the ther transfer functions of the system either by blockiagram algebra or by solving simultaneous equations to



igure 1. Describing function of an element subjected to coulomb friction

obtain the system transfer function (output as a function of error). For example, consider a control system characterized by $K(X_{in}-X_{out})=K(\text{Error})=(Ms^2+Ds)X_{out}+F_{F_1}$. The system transfer function is $X_{out}/\text{Error}=K/(j\omega)^2M+(j\omega)D+j4C/\pi|X_{out}|$, and is a function of amplitude and frequency. The validity of this relation has been checked analytically for $M=D=0$ and has been checked using an analogue computer for M and D not equal to zero.

The describing function of Figure 1 has been used to analyze the effect of coulomb friction on the performance of the Massachusetts Institute of Technology Numerically Controlled Milling Machine.[2] The controlled member of this machine was observed to wander at a low frequency with no command signal input. The system describing function obtained by the foregoing procedure is

$$\frac{X_{out}}{\text{Error}}=\frac{K_a(1+j\omega\tau)}{(j\omega)^2(1+j4C/\pi K|X_{out}|)} \tag{1}$$

where K_a has the dimensions (1/second²), τ(seconds), K(pounds/inch), C(pounds), X_{out} and Error (inches), and ω (radians/second). C is the magnitude of sliding coulomb force and the other parameters are obtained by linear analysis of the system components.

Relation 1 will be equal to -1 and the closed loop system will be unstable where $\omega=\sqrt{K_a}$ and $\omega\tau=4C/\pi K|X_{out}|$ or $|X_{out}|=4C/\pi K\tau\sqrt{K_a}$. The amplitude X_{out} and the frequency ω of the unstable condition were calculated for various values of K_a and τ. The calculated values checked the observed values on the machine when the machine was set up with the same K_a and τ. Through this analysis it was possible to select a system modification which would reduce the wander to a magnitude within the accuracy specifications.

In the foregoing example, the algebraic form of the nonlinear describing function makes the investigation of system stability a relatively simple task. In other problems, it may be necessary to represent the system function in the complex plane as a function of frequency and amplitude: that is, as a family of curves.

In any case, there is no general panacea for coulomb friction; however, the procedure described here does permit the investigation of compensation schemes and design modifications aimed toward the improvement of system performance.

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A New Liquid-Filled Current Transformer

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THE IMPORTANCE OF CONTINUITY of service in modern power systems demands that current transformers for operation of meters and control devices be properly applied and designed to give high accuracy, trouble-free operation, and long life. Improved materials, new manufacturing techniques, and novel features of design are utilized in a new liquid-filled current transformer to meet these exacting requirements.

The new line of current transformers for circuits 25, 34.5, 46, and 69 kv is designated Type *KG* and is shown in Figure 1. The principal features include the following:

1. Mechanical strength of the new Type *KG* transformer has been increased over that of the superseded porcelainclad design by use of a straight porcelain of smaller diameter and the mounting of the core and coils in a small steel tank. This cylindrical porcelain is of simpler design and easier to manufacture than the earlier type. In the event of accidental breakage, the new porcelain may be replaced without lowering the liquid below the coils.

2. The Spirakore magnetic circuit utilizes high-permeability grain-oriented steel for minimum flux path and low exciting current. Biased-core compensation permits further improvement in metering accuracy.

3. Effective sealing against air and moisture is accomplished by a welded tank, cover, and secondary glass bushing, together with retained Nitrile rubber gaskets throughout. Primary studs which pass through the straight, cylindrical high-voltage porcelain, as well as the liquid level gauge, are sealed with retained gaskets held under pressures above 500 pounds per square inch by Belleville beryllium-bronze spring washers.

4. The co-ordinated insulation structure employs new crepe paper, inert filler, paper and formed kraftboard cylinders, and oil in combination. Moreover, this semi-elastic insulation, inert filler, and configuration of parts, together with relief diaphragms in the tank, co-operate t relieve high internal pressure should it occur.

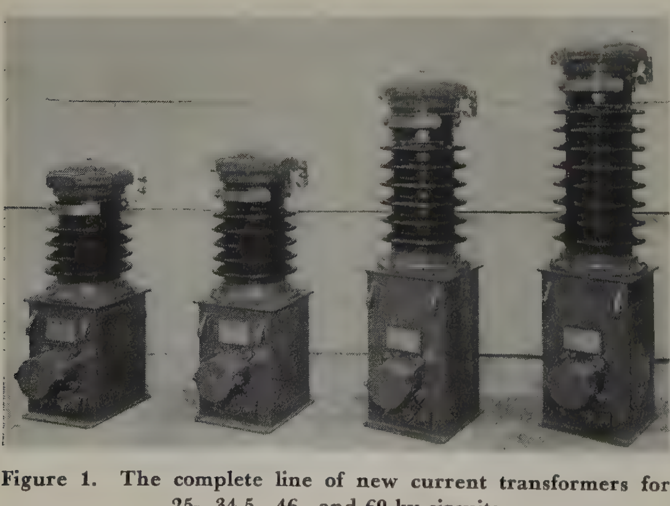

Figure 1. The complete line of new current transformers for 25-, 34.5-, 46-, and 69-kv circuits

5. Improved, high-density crepe paper insulates th primary coil and extends up a copper tube enclosing th leads. This construction results in a long creepage pat from leads to ground, thus improving the dielectric strengtl Mechanical strength of the new manila kraft paper h been increased three to four times, and dielectric strengt by 20 per cent over the former kraft crepe paper.

6. The dielectric stress over the primary bushing a sembly, both internal and external, is controlled by ele trodes in a soft-paper oil-impregnated cylinder locate just within the porcelain. This cylinder serves thr functions: (*a*) to support the electrodes; (*b*) to provic insulation between leads and cover; and (*c*) to act as barrier between results of internal arcs and the porcelai

7. Provision of relief diaphragms in the sides of tl tank to vent any excessive pressure which might occur du to an internal arc. The time constant of the relief di phragms is co-ordinated with the increase in pressure i such a manner that the vents are designed to open befo pressure can rise to excessively high levels.

8. The volume of the expansion space at the top reduced by the use of a laboratory-controlled sand fill which displaces liquid content, thus permitting the desig of a streamline cap of pleasing appearance. This ine filler also aids in the operation of the relief device an because of its higher dielectric constant, reduces tl stress in the oil between primary and secondary winding Its dielectric strength is comparable to that of oil.

Benefits of these features, as demonstrated by test, a

1. Negligible radio influence voltage compared wi proposed low National Electrical Manufacturers Associ tion levels.

2. No visual external corona over the porcelain line-to-line voltage, when clean and dry.

3. No measurable internal corona at the 60-cycle te voltage.

4. Insulation not damaged by severe steep-front impul waves, as proved by three applications of 755-kv cres 1,000-kv per microsecond, to the 69-kv transforme followed by full-wave impulse voltages.

5. Satisfactory operation of the relief device whe subjected to internal arcs between windings of over 20,0 amperes a-c component and 50,000-ampere initial cres

6. No leakage under full vacuum detectable by mass spectrometer leak detector on the primary stud an porcelain assembly after 7 weeks on accelerated life tes

Digest of paper 53-39, "A New Liquid-Filled Current Transformer With Novel Fe tures," recommended by the AIEE Committee on Transformers and approved by t AIEE Technical Operations Committee for presentation at the AIEE Winter Gene Meeting, New York, N. Y., January 19–23, 1953. Not scheduled for publication AIEE *Transactions*.

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Activities of the Electrical Equipment Subcommittee, Refining Division, of the American Petroleum Institute

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A Subcommittee on Electrical Equipment of the Committee of Refinery Equipment of the American Petroleum Institute has been formed to write the rules of Recommended Good Practice for the refining industry. The aims of this group are of interest to designers, manufacturers, and installers of refinery equipment.

FORTY YEARS ago, the AIEE appointed a Marine Committee whose members were charged with writing the rules of Recommended Good Practice for Marine :lectrical Installations. Over the years, this committee robably has done one of the most outstanding jobs for ndustry that has been accomlished by any of the Founder ngineering societies.

Three years ago, the writer vas asked to take over the hairmanship of the Subcomnittee on Electrical Equipnent of the Committee on Refinery Equipment of the American Petroleum Instiute (API). The purpose of his subcommittee was to write the rules of Recommended Good Practice for Electrical Installations for the Petroleum Refining Industry. The writer, seeing the parallel by is long association with the Marine Committee of the AIEE, thought this charge to be a wonderful opportunity o have a combined API-AIEE committee and to have the reparation of the rules of Recommended Good Practice joint undertaking. To this end, members of the API ommittee are members of the AIEE.

Our API committee, being mindful of the size of the etroleum industry and conscious of the fact that there are nany refineries which do not have electrical engineers or lectrical engineering departments, realized that much was o be gained by the establishment of recommendations which can be accepted by the petroleum industry, as well s by the manufacturers of equipment and the engineering ontractors who both design and construct refining units. t must be realized, of course, that this is a very large job nd can be accomplished only by a hard-working comnittee of able, earnest engineers, who we are proud to say onstitute our committee. We believe, probably in a ear from now, we will be able to publish our first book of Recommended Good Practice and then try to establish a evision every 2 or 3 years, which is the system followed by he AIEE in their committee work mentioned in the oregoing.

SCOPE OF SUBCOMMITTEES

WE DIVIDED our committee into subcommittees and assigned the work as follows:

Heating Devices, Instruments and Alarms, Lighting. These sections of our recommended practices contain equipment specifications which we feel are essential to the petroleum industry, particularly from the standpoint of safety. Not all of the subject items are developed to the point where use in a hazardous area does not require additional and separate means of protection. In these cases a guide for safe application is provided. Here again proved installation and maintenance practices are offered in addition to preferred materials and design. It is believed that standardization or some approach to it will accomplish a great deal with this type of equipment where only recently has there been any indication of real progress in meeting the needs of the industry.

Portable Equipment. The use of portable equipment and devices is generally avoided in the refinery for obvious reasons. However, the large-scale construction and maintenance operations working on close schedules require the use of such items as electric welders, handling equipment, hand and temporary floodlights, and instruments of various types. The practices to be recommended by the committee governing the use of this portable equipment will include electrical and mechanical requirements for selection and installation of receptacles and cable used with this equipment, and for the most part will supplement existing code requirements. The importance of good maintenance to insure safe conditions in the use of portable equipment is recognized and will be covered also.

Communications and Signals. Because the area containing the refinery is necessarily large and the hazards of fire and explosion present, a dependable trouble-free communications system is vital. The proposed regulations for this utility are presently being considered and will attempt to point out applicable code requirements, usual definition of responsibilities between the telephone company and refinery, construction methods, and special alarm circuits such as fire protection and other emergencies. Generally preferred types of equipment for various applications will be covered together with sufficient installation and main-

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

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tenance information to guide the designer properly. Special equipment, such as sound-powered systems, will be discussed and recommended for appropriate service.

Overhead Lines. This section, probably the most comprehensive prepared to date, probes into every conceivable factor directly associated with the design and installation of overhead lines. Considered by many refineries to be the most satisfactory method of delivering power, control, and communications, the overhead lines, though more economical, require more consideration from the standpoint of supports, clearances, insulators, mechanical loading, isolating devices, and terminations. These generally approved practices, in addition to covering in detail the running of lines on poles, towers, and buildings, establish a guide for proper selection of line materials and various types of cable.

Underground Distribution Systems. The practices and recommended design points connected with underground distribution systems for the refinery are covered here from the planning stage through installation. Numerous problems peculiar to the petroleum refinery, such as available space, hazardous areas, corrosive soil, and water, increase the difficulties of selecting best materials and installation design. These recommended practices based on considerable experience attempt to guide the petroleum engineer and designer through these problems with sound information regarding location of lines, manholes, underground duct systems, drainage, buried cable, cable protection, splices, materials, and so forth.

Motors, Generators, and Control. Recommendations relative to selection and application of motors and control are subdivided into a-c and d-c motors, a-c and d-c control, and generating sets. Preferred types of equipment for refinery applications are listed with recommended standard characteristics such as frequency, voltage, ratings, and mechanical design. To increase the scope further, the many unusual service conditions under which these types of equipments will operate are classified with recommendations for meeting these conditions through use of proper specifications. Miscellaneous items, such as acceptance tests, maintenance practices and procedures, and spare parts are also covered.

Wiring Practices. This section is concerned primarily with general specifications on rigid steel conduit, pull boxes and conduit fittings, and more detailed specifications on wire insulation. Recommendations for proper selection of wire insulation are included together with general information relative to installation. Specific points which are commonly overlooked, such as termination of wire in oil to prevent siphoning of the oil, are also covered. An attempt is made here, as with other recommended practices, to cover the problems frequently encountered in the refinery and present the proved methods of solving them.

Switchgear. This set of recommended practices is necessarily broad in scope as the selection of switchgear for refinery use, in addition to consideration for installation in hazardous areas, is dependent on the types of distribution system required. Also, included here to complete the picture in so far as switchgear selection and application ar[e] concerned, are such closely associated topics as relayin[g], instrumentation, control power, and automatic transf[er] schemes. Substation and load center arrangements t[o]gether with general circuit design are covered briefly t[o] provide a guide for the designer in the selection of reliab[le] power distribution.

The subcommittees working on each of the foregoin[g] send their material in to an editing committee who no[w] has two sections ready for printing: Overhead Lin[es] and Underground Distribution Systems.

We desire the help of the entire membership of th[e] AIEE in order to keep an enthusiastic interest in th[e] work, and we therefore have planned a general session [at] the API Mid-Year Meeting for Refining in New Yor[k,] N. Y. Prior to this meeting we have had papers on electri[c] distribution systems, surges, suggesting causes and effec[ts] and a paper on wire of all kinds, including the variou[s] insulations with emphasis on plastic types. We hav[e] had a paper on cable, including recommended types t[o] eliminate rigid-conduit installations; a paper on contr[ol] gear for the oil industry; and a paper on explosion[-]proof motor design and applications to the petroleu[m] industry.

At our 1953 Mid-Year Meeting, mentioned previousl[y,] we will have four papers scheduled: one on explosionpro[of] electric equipment enclosures; one on public utilit[y] applications to the oil industry; one on maintenance [of] electric motors; and one on maintenance of switchgea[r.] The committee looks forward to that meeting and trus[ts] that it will bring forth a fine attendance and much con[]structive discussion.

CURRENT PROBLEMS

The committee has taken an assignment from th[e] Refinery Equipment Committee which, we believ[e,] is of great interest to all electrical engineers and one of th[e] most difficult assignments imaginable: to define what [is] a hazardous location. By diligent work of some of ou[r] committee members, it now looks as though within [] months we will be able to come up with an intelligen[t] answer which can be used as a guide in the selection [of] electric equipment for use in the refineries in hazardou[s] locations. It is evident from the work that differen[t] individuals in the committee have done that there is n[o] unanimity of thought in this country even on the type [of] equipment to use when it is an agreed hazardous locatio[n.] This is evidenced by the large divergence in practic[e] as indicated by the contractors' proposals. Furthermor[e,] it is indicated that there are a considerable number [of] people in this country, both in the refining industry [as] well as the contracting industry, who are not aware th[at] explosionproof equipment is available. It is this differen[ce] of opinion and difference in experience that brings to th[e] committee work valuable information, which we hope ca[n] be incorporated in the recommendations being promu[l]gated. As an example of this, the committee is almo[st] equally divided as to whether the power lines for th[e] installations in refinery units should be run overhead [or] underground. There is, of course, much to be said [on]

oth sides, but it is hoped that it can be so set forth in the ecommendations that for any given condition the refinery an select the better one to use.

There is still great division in the industry between outoor switchgear and switchgear that is housed in buildings. ome refiners, being cognizant of the high cost of buildings, se nothing but outdoor switchgear and it has been emiently successful; whereas, many still use indoor switchear with expensive buildings that have to be heated, ghted, and so forth. It should be borne in mind that lectric equipment, unlike mechanical equipment, if deigned correctly, installed correctly, and let alone, probably vill operate longer without attention or maintenance than ny type of equipment we buy today.

One member of our committee is a member of the subommittee of the National Electric Code. He represents ur committee there and is doing diligent work in connecion with keeping the Code up to date and applicable to ur work. We also have a member of our committee on he American Standards Association, on standards for conluits and so forth.

The work of our committee can go ahead only if everyody turns in to help us, because there is so much work to e done. It must be kept in mind that in preparing these ecommendations, they must be written so that people, who o not have the background and experience of some others, an gain by them.

It is the writer's opinion that our ultimate goal will be n API-AIEE recommendation, just as there has been eveloped an API–American Society of Mechanical Engineers code for fired and unfired pressure vessels.

It should be very clearly understood that we are not ttempting to make rules. We are not attempting to do nything that will affect codes in any locality, or the National Electric Code. Our Recommendations for Good Practice are merely to augment, by suggestions, the right way to do a given electric installation. If that is successful, it will bring about standardization of equipment for refinery installations, and if that can be accomplished, everyone in the industry of course will buy equipment for less money.

INCREASE OF ELECTRICITY USED

It is interesting to note that 35 years ago a refinery used 1 kilowatt-hour per barrel of crude oil charged to the refining units, and today they use upwards of 5 kilowatt-hours per barrel charged. In that span of years, as a result of this trend together with greatly increased crude throughout, the increase in the use of electricity in the refining branch of the industry alone has been approximately 4,500 per cent. Is this not, therefore, good reason why both the AIEE and the API should not get to work on this long overdue project?

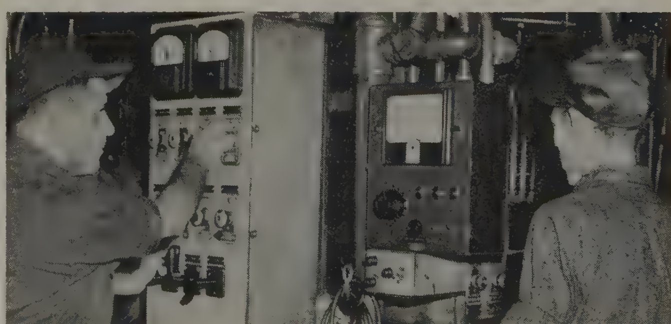
In pointing out some of the foregoing facts, it should be evident that the potential usage of electricity and electric equipment in the refining industry is far greater than most people imagine. While nothing has been found or published relative to the total amount of electric equipment sold in the petroleum industry, it might be well worth while to see such data some day in dollars and in types of equipment.

Just to give a small example of what is meant, a large catalytic cracking unit is being built now that in one unit will use two 2,500-horsepower, one 3,500-horsepower, one 4,000-horsepower, and one 5,000-horsepower motors—all operating at 13,200 volts. This is in one refinery unit, not to mention all of the various small motors in the same unit. This example is given just to show how rapidly refining electrification is going. As long as we can substitute engineering for manpower, this growth will continue even at a more rapid rate. The committee, therefore, solicits the co-operation of all electrical engineers who have knowledge and experience to contribute.

X-Ray Gauge Controls Rolling Mill Equipment

X-ray gauges to control thickness of copper alloy strips ave been installed by Chase Copper and Brass Company. The gauges, operating on 155-volt a-c lines, contain a comact high-voltage source and X-ray tube, both shielded o be entirely safe. The source unit is placed about 8 nches beneath the strip at a point within 2 feet of the rolls. A small hole in the top allows a tiny X-ray beam to pass pward through the moving strip. When the mill is not perating this aperture is blocked automatically with a hield-guard.

After the X-ray beam has passed through the strip, it asses into a small pickup device that is mounted over the trip directly above the aperture in the source unit. The ickup unit converts the X-ray energy into electric energy which is amplified and fed into a zero-counter meter caliorated to indicate deviation from nominal gauge. Maxinum readings indicate a variation of plus or minus onetenth of the strip thickness. The scale is graduated so that readings of as little as 0.000050 inch can be obtained on the thinnest strip rolled.



Automatic control of copper alloy strip thickness is obtained by X-ray gauges. Visual indication of strip thickness is shown on meter between roll operators

Wire and Cable in the Telegraph Industry

W. F. MARKLEY

THE TECHNICAL ADVANCES in the art of telegraphy, resulting in the fully automatic selective-switching system in a modern telegraph office, have necessitated major improvements in the wire and cable network, particularly in the mechanized communication centers, to insure efficiency of operation and dependability of the complex electronic equipment in continuous operation over a wide range of frequencies and operating conditions. In each of these centers, the proper functioning of the high-speed equipment is dependent upon the performance of some 3,000 miles of high-grade wire conductors and more than 1,000,000 intricate wire connections.

Instrument wires insulated with extremely thin walls of extruded vinyl insulation (synthetic-resin compounds of polyvinyl chloride or its copolymer with vinyl acetate), processed to meet severe physical and electrical requirements, and over which is applied a thin protective extruded nylon jacket, represent novel designs for general use in wiring equipment and apparatus. In special applications natural polyethylene is substituted for the vinyl insulation. Fluorothene-insulated wire is also employed where unusual chemical stability is required. These new standards have many advantages over former types of rubber or vinyl insulation and lacquered cotton or rayon servings or braids.

For inside multipair cables employed for wiring offices, vinyl insulation and nylon jacket for the conductors replace the previous enamel and textile covering, and an extruded vinyl sheath is substituted for the heavily flameproofed, woven cotton braid on the cable previously used for many years in the communication field. The moistureproof jacket permits the use of this cable in damp and wet locations where heretofore lead-covered cable was required. This new design, together with a novel cabling arrangement, provides improved electrical performance and substantially reduces installation cost.

In various other inside twisted-pair wires and multiple conductor cables, the adoption of vinyl insulation and nylon jacket for the conductors and an over-all vinyl cable jacket, as substitutes for rubber insulation and cotton braids, materially reduces diameters and improves performance. Woven nylon braid materially improves serviceability of switchboard cords as compared with woven cotton braid or extruded vinyl sheath.

In twisted-pair wire having an over-all woven metallic shield, required for certain circuits in electronic equipment, no significant difference in cross talk, attributable to various degrees of shield coverage, varying from 70 to 100 per cent, could be detected. The major contribution of the shield is the minimizing of direct capacitance between circuits. From a mechanical standpoint, that is flexibilit and minimum damage during severe bending, the shiel having the least coverage is the most desirable.

For outside wires used in city distribution service, in re pair and restoration work in storm areas, and in genera pole-line reconstruction projects, Western Union pioneere in the development of vinyl insulated, weatherproof braic covered conductors that out-performed the old rubbe insulated standards. Modified rigid vinyl insulation as substitute for the entire covering on this wire appears t have possibilities for this service.

Multipair line cable, employed for short runs in congeste areas, having natural polyethylene insulation and blac polyethylene jacket, is being considered in lieu of cable in sulated with dry paper and protected with the traditiona lead sheath. The vastly reduced weight of the plasti cable is reflected not only in lower cost of handling and in stallation, but also in reduced cost of the much lighter sup porting messenger and associated hardware that can b employed in aerial installations. Also, badly damage sheath that permits moisture to enter the cable has practi cally no effect on the effectiveness of the polyethylene as dielectric. From contemplated field installations, indica tions are that the cost of the plastic cable in place, as well a maintenance costs, will be substantially less than compa rable costs for standard lead-covered cables, notwithstand ing the difficulties that may be encountered in developin adequate splicing technique.

A simplified inexpensive self-supporting coaxial cable fo carrier communication at frequencies up to 30 kc per sec ond comprises a copper-covered steel center conducto insulated with a heavy wall of polyethylene over which i formed an outer copper-tape conductor applied withou spiralling. An over-all jacket comprising a wover weatherproof cotton braid provides a finished cable that i considered mechanically and economically promising. Th design appears to be extremely effective from the standpoin of reduced electrical losses and is believed suitable for tele vision frequencies if required. Attenuation is estimated a 2.0 decibels per mile at 30 kc per second. It is recognize generally that a gaseous dielectric would effect a marke reduction (ratio of 3 to 2) in the attenuation, but at presen such a design seems economically impractical.

Prior to 1940 gutta percha was used almost universall for insulating ocean cable conductors. As World War I shut off the supply of gutta percha, pressure for a suitab substitute resulted in the application by English scientis of polyethylene for this service. Indications are that poly ethylene may be substantially resistant to attack by th "teredo" worm, whereas gutta percha must be protecte with a serving of copper or brass tape.

These applications illustrate the major uses of the newe insulating and jacketing materials in the telegraph industr

Digest of paper 53-164, "Wire and Cable in the Telegraph Industry," recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Grain-Oriented Iron-Silicon Alloys

G. H. COLE
MEMBER AIEE

Ideas and procedures utilized in the development and production of grain-oriented iron-silicon alloys are presented together with the chemical analysis and some properties of these materials. Data showing the large magnetic advantage of using the material parallel to the direction in which the alloy is rolled and indicating why transformer core designs have been influenced greatly by the development are also included.

IRON-SILICON ALLOYS with highly directional magnetic properties, especially suited to transformer cores, have been in the course of development for many years. While research work on this subject has not fully matured it has reached fruition, and certainly it can be classed as successful. Further progress is continuing at a rapid rate.

The low core loss and high permeability of grain-oriented iron-silicon alloys, when the magnetic flux is parallel to the direction of rolling, make possible savings in copper and reduction in size and weight of electric equipment. Consequently, engineers today are eager to redesign more and more of their equipment to secure these manufacturing economies and operational advantages. This has created a demand for even larger tonnages of these alloys than can be produced with the facilities now available. Furthermore the demand is greatest for the grades with the best attainable magnetic characteristics. Due to this interest a report on the status of the development seems timely.

PERMEABILITY IMPROVEMENT CORRELATED WITH CORE LOSS

YEARS BEFORE N. P. Goss produced the first grain-oriented silicon steel[1] in small commercial quantities, it was recognized by engineers in transformer manufacturing companies and also by a steel supplier that a core material was needed that would permit the magnetic-flux density of transformers to be increased without increasing either the exciting current or the core loss. It was understood that grain orientation was the theoretical answer to the question as to how this might be accomplished. However, much experimental work was done before practical methods of producing such a product were found.[1–6] With the relatively unoriented electrical sheet steel previously available to the transformer industry, the operating induction had been steadily increased for approximately 30 years as improvements in steel resulted in lowering the core loss per unit weight. Some years before the new type of core material was introduced, the exciting current of the best transformer grades was quite high at the inductions which could be used without excessive core loss. This was because each substantial reduction in core loss, made as new grades were introduced, had been accompanied by an increase in magnetizing current at inductions above 13 kilogausses. This was due in part to the increase in the silicon content of the sheet metal used in the cores.

The effect upon the exciting volt-amperes of this lowering of permeability may be noted in Figure 1 and contrasted with Figure 2. Figure 2 shows the opposite trend for grades of grain-oriented iron-silicon alloys, developed under a program designed to balance improvements in core loss with improvements in permeability.

For short-time operation of transformers at voltages higher than normal, the exciting current is likely to be the limiting feature in the design. Hence during the course of this development considerable attention was given to the permeability of the core material for inductions approximately 10 per cent above normal or at a corresponding magnetizing force. We chose 10 oersteds, or 20.2 d-c ampere-turns per inch, for this control point in experimental work. For engineers accustomed only to a-c tests, it will be interesting to note that this d-c magnetizing force usually produces an induction within 1 per cent of that resulting from an excitation of 10 rms ampere-turns per inch of magnetic path. This relation of a-c and d-c magnetization at 10 oersteds applies to a wide range of silicon-iron alloys used in transformer cores.

Table I. Permeability Versus Perfection of Orientation for 3 Per Cent Silicon-Iron Alloy 0.012 or 0.014 Inch Thick

Induction at 10 Oersteds (Kilogausses)	Permeability* at 10 Oersteds	Approximate Classification of Degree of Orientation
15.5	1,550	Unsatisfactory
16.5	1,650	Fair
17	1,700	Good
17.5	1,750	Excellent
18	1,800	Exceptional

* When magnetic flux is parallel to direction of rolling.

Permeability at 10 oersteds (also the induction at this point) has been found, in the course of this work, to be a very good measure of orientation and can be determined quickly and accurately. For example, the perfection of the orientation might be correlated for development purposes as shown in Table I.

It should be noted that a decrease of only 3 per cent in

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G. H. Cole is associate director of the research laboratories, Armco Steel Corporation, Middletown, Ohio.

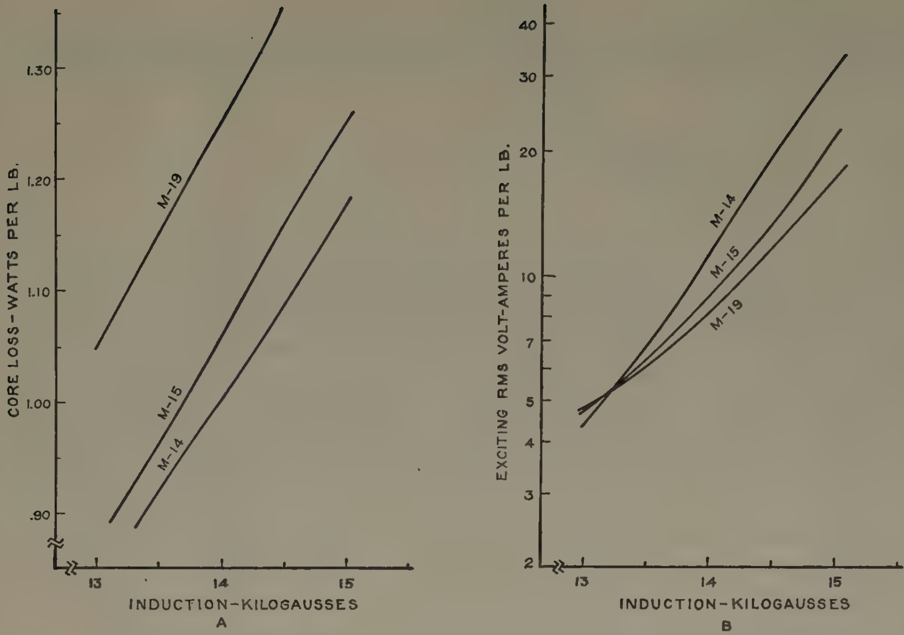

Figure 1. Conventional silicon steel. Higher volt-amperes are found with lower core loss grades (Parallel grain-tests for comparison with Figure 2)

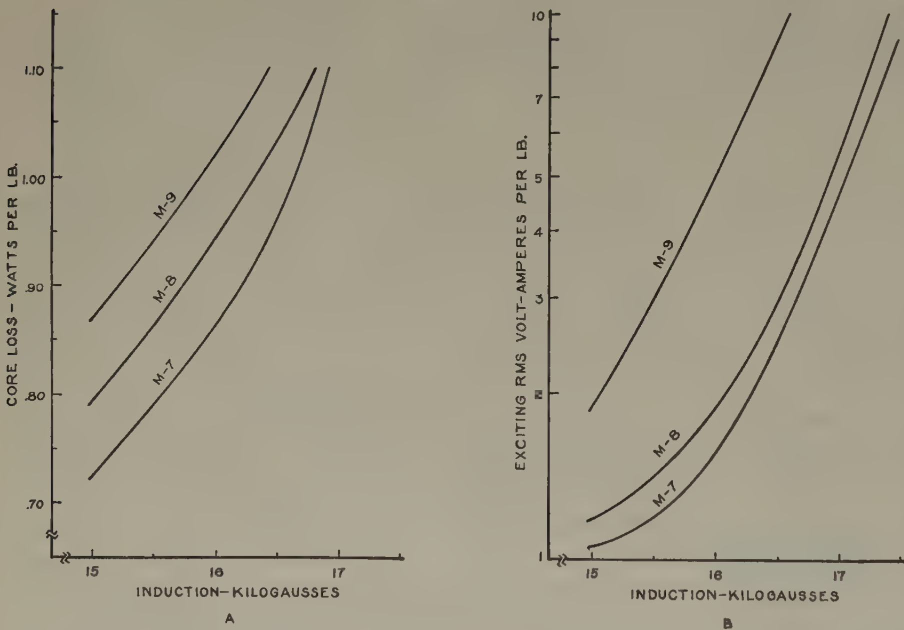

Figure 2. Oriented iron-silicon alloys. Lower volt-amperes are found with lower core loss grades. See Table II for grade names corresponding to American Iron and Steel Institute Type Numbers

the lamination factor (per cent solidity of the core) will offset the improvement of the permeability by one of these classifications. This emphasizes the need for smooth, flat laminations and the thinnest surface insulation that will be adequate.[7]

DEVELOPMENT OF ORIENTATION

DETAILS OF PROCEDURES necessary to produce grain orientation in iron-silicon alloys are stated in the patents mentioned at the end of this article. These procedures may be summarized by stating that metals of only certain analyses are suitable, hot reduction must occur under certain favorable conditions, the cold reduction usually must be made in two or more steps with the correct range of reductions in each stage, and a suitable annealing treatment given after each cold reduction. The final heat treatment must develop the latent tendencies to produce grain orientation of a special type, produce grains or crystals of the proper size and shape, and a product free from stress at the end of the processing. In the patents cited and in reference 20, the intermediate annealing temperatures range from 1,400 to 1,850 degrees Fahrenheit and the final annealing temperature is between 1,850 and 2,280 degrees Fahrenheit. The correct combination of these factors produces an orientation of the cube-on-edge type[8] with the edge of cube of the elementary components of each crystal or grain of the alloy in the plane of the sheet and parallel to the rolling direction.

The commercial product, however, consists of crystals with their major dimensions somewhat greater than the thickness of the sheet and with the elementary cube edges usually within 10 degrees of the most desirable orientation just mentioned. Yet contrary to some published information, orientation does not imply that the grains are elongated in the finished product. Indeed, the directional characteristics of this product are not revealed by a macrograph, see Figure 3. Furthermore, silicon steel should not be classed as oriented simply because it is cold reduced. Some classes of cold-reduced electrical steel display less directional magnetic properties than certain hot-reduced sheets of somewhat similar analysis. The directional effect upon permeability at high induction produced by orientation is shown by Figure 4.

CORE LOSS

THE ELECTRIC POWER EXPENDED in the magnetization of magnetic materials, usually called core loss, generally is the most important criterion of magnetic quality for grain-oriented iron-silicon alloys as well as for other electrical sheets.

Grain orientation of the type described in this article markedly reduces the hysteresis component of core loss when magnetic flux is parallel to the direction of rolling.

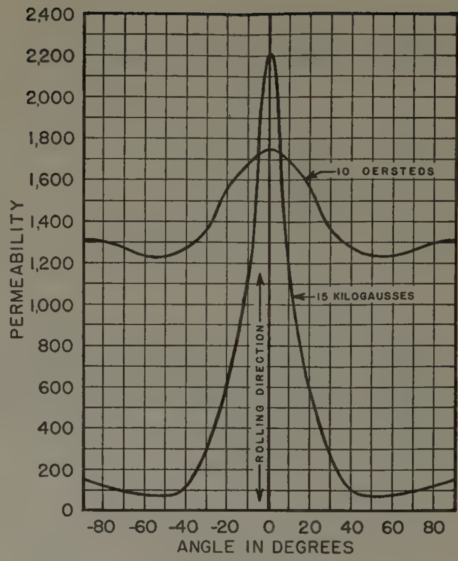

Figure 4. Permeability at 15 kilogausses and also at 10 oersteds at various angles to the rolling direction: Oriented iron-silicon alloy, American Iron and Steel Institute Type M-7, TRAN-COR 3X-0

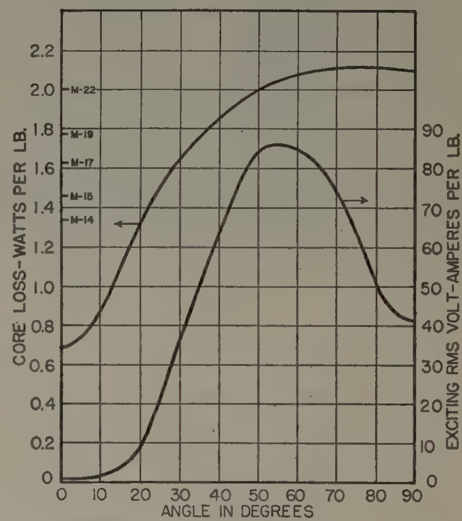

Figure 5. Core loss and exciting rms volt-amperes at 15 kilogausses and 60 cycles at various angles to the rolling direction for oriented iron-silicon alloy, Type M-7, TRAN-COR 3X-0. (Test limits for conventional silicon steel grades are indicated at the edge of the chart)

In the better grades of oriented iron-silicon alloys, the hysteresis is less than half as great in the direction parallel to that in which the metal was rolled as at 55 or 90 degrees to this direction. Likewise, the core loss is usually less than half as great in the parallel direction even though the eddy component is nearly the same in all directions in the metal and is a sizable proportion of the core loss. See Figure 5.

Typical core loss and excitation curves for the inductions of greatest interest are shown in Figure 6 for one of the well-oriented grades, TRAN-COR 4W-0, now being produced in large tonnages in a thickness of 12 mils. The maximum test limit for this grade is 0.64 watt per pound at 15 kilogausses and 60 cycles. A companion grade TRAN-COR 3W-0 has a test limit of 0.71 watt per pound.

NEW TEST CONDITIONS

In making comparisons of the magnetic quality of oriented grades with other classes of electrical steel, it should be noted that the core-loss tests to determine the grade of material are made under somewhat different conditions from those for conventional core materials.

Conditions simulating those under which the electrical industry uses most of the oriented core material have been adopted for standard test procedure, so as to insure that the development work produces the characteristics most important to the industry. In simulating operating conditions, the test specimens of this type of core material are magnetized in a direction parallel to that in which the metal was cold reduced. Its magnetic properties are best when utilized in this manner. In most new designs of transformer cores, changes have been incorporated to utilize this directional characteristic to advantage.

The standard test induction is 15 kilogausses, the highest of the two inductions used in grading transformer steel. This is because the new core material usually operates at substantially higher inductions than those used formerly in transformer cores. Contrary to previous general practice, the test specimens are annealed after shearing to the specified size. This is done in a further effort to simulate the usual treatment of core materials before their assembly in transformers. These differences should be observed in comparing data, such as shown in Figures 1 and 2 on the two types of core materials; and also in making allowance for changes in magnetic characteristics produced during the fabrication of the cores.

GRADE DESIGNATION

Designations assigned by various manufacturers and fabricators to their grain-oriented iron-silicon alloys, or the cores fabricated from them, are listed in Table II. Note that the American Iron and Steel Institute (AISI) Type Number is approximately ten times the core loss limit and that a number of the trade designations are also related to the test limit for core loss. One of the best-known names, Hipersil, was registered as a trade-mark as early as 1934. This name was given the material and also

Table II. Grade Designations of Oriented Iron-Silicon Alloys

AISI type number	*M-10*	*M-9*	*M-8*	*M-7*
Core loss limit (watts per pound) for 0.014 inch, 15 kilogausses, 60 cycles	1.00	0.90	0.80	0.73
Trade Name		**Symbol of Grade**		
Tran-Cor			2X-0	3X-0
Silectron	100	90	80	73
	T-100	T-90	T-80	T-73
Crystaligned			80	73
Orthosil		X	2X	3X
Alphasil	55			
Unisil		3	2	

to cores of iron-silicon alloys with well-developed orientation of the desirable type. Although in the early stages of the development of this product the name was applied to grades that at present would be considered as having com-

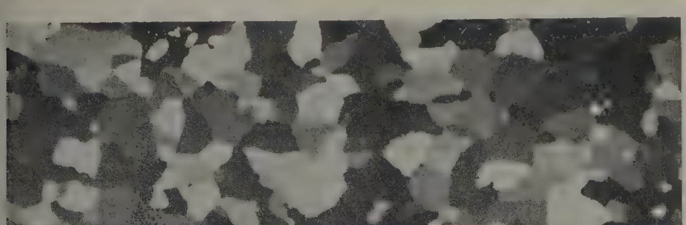

Figure 3. Macrograph on oriented iron-silicon alloy showing actual size and shape of grain

paratively high core loss, it now applies only to the improved grades produced currently in substantial quantities.

CHEMICAL ANALYSES

The core material resulting from this development is classed as an electrical steel although the following analyses indicate a more appropriate name is iron-silicon alloys, since other elements are found only in quite small amounts. The carbon content, in fact, is kept so low that most chemical laboratories may have a test error greater than the true value. It usually is lower than such elements as nickel or copper. Hence the metal is not steel. Table III shows analyses made on oriented transformer-core sheets produced by different manufacturers.

Inasmuch as electrical steel with a silicon content approaching or even exceeding 5 per cent has been used extensively for transformer and generator steel for 2 or 3 decades, and inasmuch as it is physically possible to cold reduce 4-per-cent silicon steel to gauges usually used for 60-cycle applications, the question is frequently raised as

Table III. Chemical Analysis of Three Lots of Grain-Oriented Iron-Silicon Alloys

Specimen	C	Mn	S	Si	Cr	Cu	Ni	Mo	Sn	Bal.
A	0.006	0.040	0.005	3.17	0.007	0.039	0.011	0.003	0.003	*
B	0.004	0.048	0.015	3.22	0.018	0.11	0.061	0.012	0.008	*
C	0.005	0.044	0.012	3.36	0.049	0.055	0.038	0.005	0.004	*

* Largely iron.

to why the grain-oriented silicon steels generally have a silicon content in the range 2.7 to 3.5 per cent. This silicon content is high enough to insure freedom from phase change when the material is heated to a high annealing temperature, an important consideration in oriented alloys. The need for higher permeability at high induction when the core loss is improved was also an important consideration in choosing a lower range of silicon content for the new core material. Although higher silicon content would result in a slightly lower eddy-current component of core loss, this can be attained more economically by a reduction in thickness.

THICKNESS OF SHEET

Orientation of the special type generally desired for transformer cores can be produced in iron-silicon alloys in a wide thickness range; yet cost of production and fabrication restricts their use to rather narrow ranges for each frequency. Figure 7 shows how a reduction in thickness could reduce the core loss for 60-cycle applications if it were not for this cost factor. The test data used for this curve were obtained on oriented alloys of AISI Type *M-7* having the same silicon content (3.15 per cent) and permeability (1,700 at 10 oersted or an induction of 17 kilogausses). They were also similar in other respects.

Due to a combination of production and economic factors, most of the tonnage of grain-oriented iron-silicon alloys for 50- and 60-cycle applications has been produced in thicknesses of approximately 12 to 14 mils, 0.3 to 0.35 millimeter. Various thicknesses between 12 and 14 mils

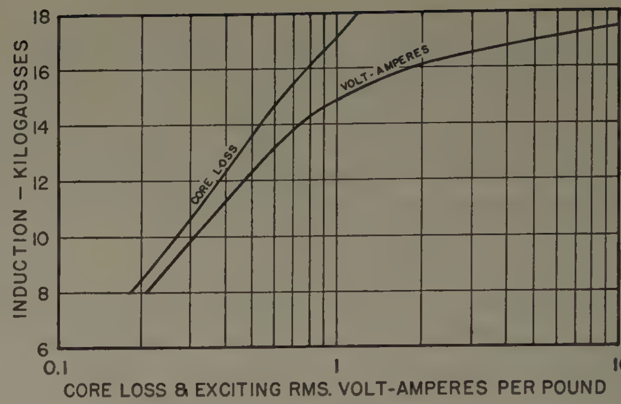

Figure 6. Core loss and exciting rms volt-amperes at 60 cycles for 0.012-inch oriented iron-silicon alloy, TRAN-COR 4W-0

have been tried, but now 12 mils is being widely used for wound or wrapped cores operating at power frequencies. The 14-mil material is used chiefly for sheared and punched laminations of large power transformers, large generators, and small cores made of stampings.

The need for flexibility of the strip at a minimum increase in cost has dictated the use of 12-mil material for wound cores. This is especially true of those manufactured by annealing the wound cores in their final shape, unwinding them and cutting sections to the desired length, and feeding these cut lengths into form-wound copper coils. In manufacturing cores by this procedure it is important to avoid stressing any substantial portion of the core material beyond the elastic limit after the final anneal. Permanently bending the material in assembly to any form differing from that prevailing during the annealing of the core results in a deterioration of the magnetic properties.

A strip thinner than 12 mils might produce even better magnetic properties in the core; yet its cost for 60-cycle applications must differ but little from that of one wound from 14-mil strip. One way of keeping down the cost of

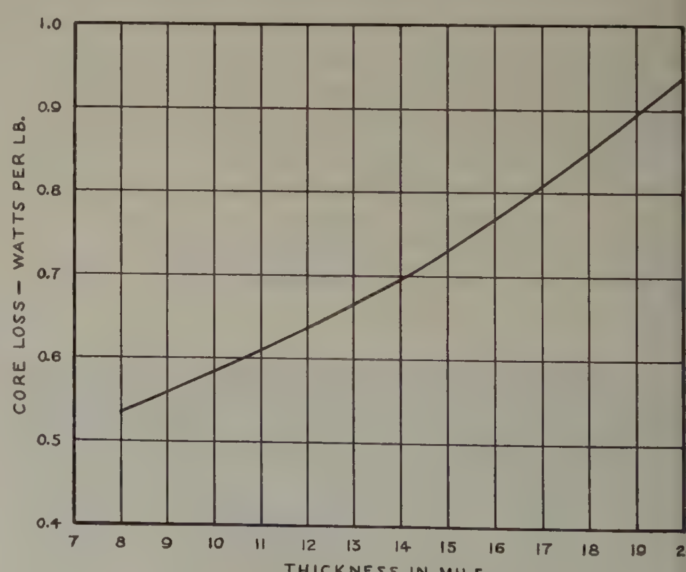

Figure 7. Influence of thickness on the core loss for oriented iron-silicon alloy, AISI Type M-7 at 60 cycles and 15 kilogausses

the thinner strip is to avoid the necessity for a special processing step to apply insulation to the sheet metal. The surface film that can be formed during high-temperature annealing under certain conditions[9] has been found to produce adequate insulation for transformers of approximately 100-kva and smaller capacity.

Oriented iron-silicon alloys have been produced commercially for several years in thicknesses of 1, 2, and 4 mils (0.025 to 0.1 millimeter)[10] for applications[11] involving frequencies from 400 to 100,000 cycles, or where the flux wave shape, as in pulse transformers, must be of equivalent steepness. Grain-oriented iron-silicon alloys are now being produced in still lighter gauges[12,13] with well-developed degrees of preferred orientation.

Due to the differences in processing required for each gauge, it is desirable to keep the number of standard thicknesses of the commercial product to a minimum. Hence thin oriented strip is usually supplied in thickness steps that vary by a factor of approximately two, with 0.014 inch being the heaviest gauge normally produced.

IMPROVEMENTS

One of the earliest improvements in this product was the elimination of excessive magnetic aging by the discovery[14] of processing methods that reduce carbon sufficiently below 0.01 per cent. Thus aging has not been a problem in recent years. The first grain-oriented alloys on the market had been given only a strip anneal at final gauge, but this did not result in high magnetic quality, judged by today's standards.

The next step was to box anneal laminations or cores at high temperatures, 2,100 degrees Fahrenheit and over. The precautions necessary to insure success with this procedure made it difficult for any but the largest transformer manufacturers to anneal the new core material in this manner. Even with considerable special equipment and technical supervision of annealing by the transformer manufacturer, there always was uncertainty as to whether the laminations would develop the properties required to meet the magnetic test limits of the specified grade. As a result, larger uneconomic margins of design were required.

Hence many engineers consider that a real advance had been made when the steel mills produced sheets or coils with the magnetic properties fully developed and the grade established for each shipping lot. An anneal at less than 1,500 degrees Fahrenheit by the fabricator of the laminations or core was then adequate to restore the magnetic properties by elimination of stress introduced by his operations. This anneal required much less technical supervision, involved fewer hazards, and cost much less than the high-temperature anneal given the cores after their fabrication.

The development of core insulation[15,16] to withstand annealing temperatures made it possible to produce wound cores that did not need to be uncoiled after annealing to eliminate adhesions between strands. Applying this insulation before fabricating greatly broadened and facilitated the use of wound cores. Such cores are especially suitable for distribution transformers as they utilize the directional properties to best advantage. ARMCO number *4*, CARLITE, and Allegheny-Ludlum *C-10* are examples of this type of surface insulation.

Still other developments, reference 17 for example, have resulted in improved orientation and thereby raised the permissible operating induction in transformers.[18] A recent marked improvement in flatness, gauge control, and uniformity of magnetic properties has increased the value and usefulness of this product. In fact a considerable proportion of the research and development effort expended on this product in recent years has been devoted to improving these characteristics.

Figure 8. Oriented iron-silicon alloys can be furnished in coils weighing 4 tons each

COMMERCIAL PRODUCTION

Transformers, from those weighing a few grams to the largest power rating, have been built with grain-oriented iron-silicon alloy cores. Many of the largest turbine-generators are being constructed[19] with the new core material, even though it can not be used to its maximum advantage in such equipment.

Much of the tonnage of grain-oriented iron-silicon alloys has been supplied in coils weighing a few tons each, such as shown in Figure 8, but it frequently is furnished in narrow coils that have been slit to the width used by the transformer manufacturer.

During the past 10 years nearly all of the grain-oriented iron-silicon alloys have been produced by two or three American steel makers, the annual production being several thousand tons. Previously many tons of the new material were produced under rapidly changing experimental conditions. During this early period, hope and confidence were instilled that a practical and economically valuable product would be perfected.

In the early stage of the development, several manufacturers of electric equipment also were risking a great deal of money in learning how to use commercially this new material that had been in the laboratory stage as early as 1933. Now European steel makers are beginning to learn how to produce transformer-core steel of the new

type. Their present status is similar to that of the American development of more than a decade ago.

In this country production now has reached a high rate. Recently *Iron Age* estimated that "Close to 150,000 tons of grain-oriented silicon steel will be made this year (1952). . . Tonnage may double next year."[20] Although production has been doubled again and again in recent years the prediction for 1953 seems high, both because of the large investment required in one year and the difficulty of new suppliers quickly learning the technique of producing core material of very high quality. These figures do indicate, however, the stage of great commercial importance that has been attained.

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EUSEC Conference on Engineering Education

The conference of representatives from the engineering societies of the United States and western Europe was held in London, England, January 12–17, 1953, and was sponsored by the International Committee on Engineering Education of the United States and the European Council of Engineering Societies (EUSEC).

European countries represented were Norway, Sweden, Denmark, Western Germany, Holland, Belgium, France, Switzerland, Italy, and the United Kingdom. The United States delegation, which was sponsored by the Engineers' Council for Professional Development (ECPD), was made up of Dean Thorndike Saville of New York University, chairman of the ECPD Education Committee; Dean W. R. Woolrich of the University of Texas and president of the American Society for Engineering Education, and Dr. L. F. Grant, chairman of ECPD.

The conference was for the exchange of ideas and no attempt was made to reach conclusions. The discussions were valuable in clarifying the different systems and in developing a mutual understanding of the principal methods of engineering education in the several countries.

The first two sessions were devoted to reports prepared in advance by a delegate from each country and comments and questions on these reports.

The third session was given over to "Standards and Criteria of Entry." Some of the standards for entry to formal engineering education seemed rather surprising to those accustomed to the American procedure. For instance, in Britain the standard of entry into a university is a year higher than that generally required here.

The next discussion was on "The Place of Basic Science and Technological Studies in the Education of the Engineer." In general, the delegates agreed that it was not possible to produce a competent engineer by university work alone.

"The Place of General Studies With Special Reference to the Humanities in the Education of the Engineer" was the subject next discussed. One experiment mentioned, which apparently has been very successful, constitutes setting aside 1 hour a week for a lecture on cultural subjects.

"The Practical Training Necessary for Qualification as a Professional Engineer" dealt with training in industry. There is in none of the other countries the legal system of examining and licensing engineers found in the United States and Canada. This discussion led to the next on "The Full Requirements for Conferment of Professional Status." In Sweden, Switzerland, Belgium, Norway, France, Holland, and Germany, there is required a diploma from a college recognized by the government, and in the United Kingdom professional status depends on membership in a professional Institution. All countries seem to provide written examinations for those engineers who have not graduated from a recognized university and who through practical experience and private study have fitted themselves for professional status.

The final session was devoted to plans for the future and EUSEC was asked to authorize another conference in 1954 and that in the interim a committee prepare a glossary of terms in common use so that they would have the same meaning for all the delegates.

System Stability Limitations and Generator Loading

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STEADY-STATE OR TRANSIENT STABILITY problems are not significant limitations on most power systems today. However, under some circumstances it is logical to split existing systems and perhaps add reactors to prevent costly increases in interrupting capacity of circuit breakers. It has become apparent recently that transient stability problems can readily develop if this approach is carried too far.

Most power systems designed in accordance with modern concepts inherently have sufficient stability margin to allow reasonable operating flexibility both in generator voltage and kilovar output. System design rather than machine characteristics determines safe power loading and operating flexibility.

Occasionally, systems may be designed so that conditions develop which require reduced generator operating flexibility to maintain adequate stability margins. These conditions are characterized by high system reactance as viewed from the generator terminals. This high reactance can readily result from the splitting up of the system. In this case the normal reactance may be low and the high reactance results from the loss of a heavily loaded line or other facility. Transient, rather than steady-state stability, therefore becomes the determining problem.

The most important single factor in determining stability margin is system reactance, as viewed from the generator terminals, after the system disturbance is over. So long as this final reactance—based on the maximum turbine capability of the machines connected to the generator bus—never exceeds 50 per cent, and high-speed switching is used (6 to 7 cycles), stability should cause no generator operating restrictions. A conservative estimate of the safe power limit as a function of final reactance is shown on Figure 1. The kilovolt-ampere base is that corresponding to a maximum turbine capability. The system voltage is that corresponding to unit generator power at unit terminal voltage and

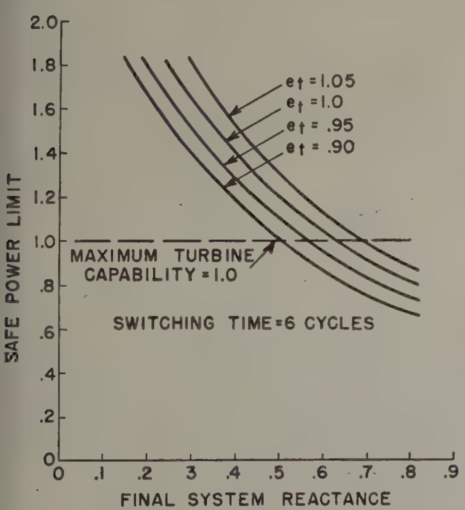

Figure 1. Safe power limit as a function of final system reactance

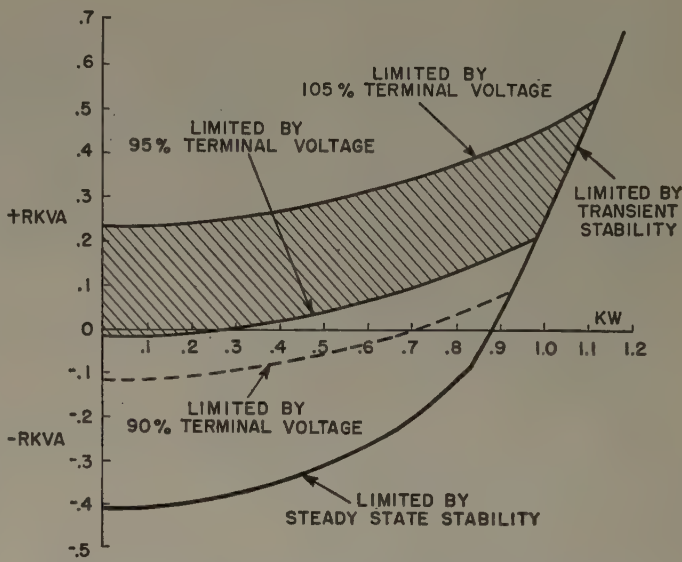

Figure 2. Operating guide for a 40/60-per-cent system

0.95 power factor overexcited. As the final reactance progressively exceeds 50 per cent, generator operating limitations in allowable voltage and/or reactive kilovolt-ampere generation quickly develop. Where higher reactances are justified, such as in the case of long-distance transmission, generator operation must be fitted to the transmission requirements.

In metropolitan power systems, physical distances are relatively short and the normal external reactance seldom exceeds 30 per cent. In this case, a final reactance of 50 per cent or more seldom occurs except over a 2-channel power flow to the system where at least one channel includes the very appreciable electrical distance of transformers and/or sizable reactors.

Where system design causes generator operating restrictions, safe operating guides showing minimum kilovar generation as a function of kilowatt loading under normal operating conditions should be developed. Figure 2 is an example of an operating guide for a system which has an initial reactance of 40 per cent and a final reactance of 60 per cent, as viewed from the generator terminals. Note that there are three boundaries to the generator operating region; two are terminal voltage limitations and one is a transient stability limitation. Steady-state stability is not a limiting factor in this example.

This analysis is based on the use of any form of generator voltage regulator with the quick transient response.

Digest of paper 53-106, "System Stability Limitations and Generator Loading," recommended by the AIEE Committees on Transmission and Distribution and System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Type O Carrier Telephone

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The Type O carrier is an economical short-haul carrier system especially suitable for use under 150 miles. It fulfills the same purpose for open-wire lines as the Type N carrier system does in cable routes. Numerous laboratory tests have indicated that good service standards have been maintained in spite of its low cost.

TYPE *O* CARRIER, the most recent addition to the carrier series, is supplying additional telephone circuits to the many communities served by open-wire facilities. Designed for short-haul applications, it supplements, rather than supersedes, the older open-wire systems such as Types *C* and *J* designed primarily for long circuits.

Type *O* Carrier is a family of four 4-channel systems providing 16 2-way talking channels on a single open-wire pair. These systems, individually known as *OA*, *OB*, *OC*, and *OD*, are suitable for use over distances up to 150 miles and will prove in for distances as short as 15 or 20 miles, the exact distance depending on local conditions such as terrain, population density, and the amount of unfilled space on existing pole lines. Each system occupies a band of frequencies 36 kc wide as shown in Figure 1. The *OA* system is equivalent to a voice circuit plus a Type *C* system. The *OB* system, located in the band 40 to 76 kc, can be operated above a Type *C* system without any change in the line transpositions. The *OC* and *OD* systems are high enough in frequency so that additional line transpositions are usually required.

The Type *O* systems have been made economical for short-haul use without sacrificing high standards of circuit reliability and quality, by designing specifically for short distances, by employing built-in compandors and signaling, by the use of frogging repeaters so that only flat gain regulation is needed, by new apparatus components not previously available, by assembly-line manufacture and the use of die-casting for all framework parts, and by packaging for minimum application engineering and installation effort.

Many features, such as the built-in compandor and the built-in signaling providing for both dialing and supervision, are common to both Type *N* and Type *O* systems.

The outstanding differences between Type *O* and Type *N* systems are: The transmission of two channels as the sidebands of one carrier instead of double side-band transmission; transmission in both directions on one pair instead of separately on two pairs; a range of regulation four times that required in Type *N*.

The combination of two voice circuits on one carrier is referred to as twin-channel operation. It is an efficient use of the frequency space, requires the generation of only one carrier frequency per two channels, and permits the gain regulation of twin channels by a common circuit. The discrimination requirements in the receiving band filter are made more lenient by this twin-channel operation since the carriers are 8 kc apart and the "unwanted" energy that gets through the band filter from some other twin will demodulate as frequencies above 4 kc. These can be removed in a simple low-pass filter rather than by more discrimination in the channel band filter.

Combining the two directions of transmission on one pair introduces the need for filters to separate and combine groups. A feature of Type *O* is the way in which filters are combined and connected through plugs and jacks so that they can be rotated 180 degrees or exchanged for other types, to produce different circuit arrangements.

Each of the Type *O* systems starts with a 4-channel bank in which four separate voice circuits are modulated onto two carriers, 184 and 192 kc. This 4-channel band, 180 to 196 kc, is then group modulated into any one of the desired 16-kc bands shown in Figure 1, for transmission over the line. At repeater points the *OA* signals, 2 to 18 kc and 20 to 36 kc, are amplified and transmitted without any change in frequency so that they co-ordinate with Type *C* systems on the same pole line. The *OB*, *OC*, and *OD* signals at repeater points are all "frogged," that is each 16-kc band is group modulated to invert and translate it from the high into the low group or conversely, before it is amplified and transmitted over the line. At the receiving terminal, each of the 16-kc bands is group modulated back to the 180- to 196-kc range. Each channel is separated by its receiving-channel band filter, and demodulated to voice frequencies. A block schematic of the four Type *O* systems is shown in Figure 2.

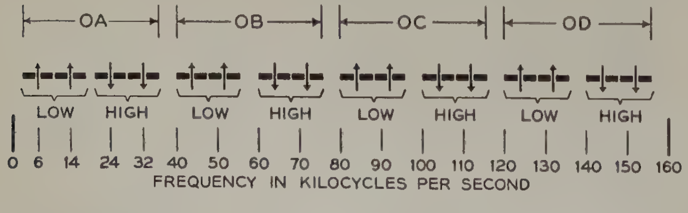

Figure 1. O carrier frequency allocation

TERMINAL

PROVISION IS MADE in the channel unit, Figure 3, for the connection of a 2- or 4-wire voice-frequency circuit.

Revised text of paper 52-307, "Type *O* Carrier Telephone," recommended by the AIEE Committee on Wire Communication Systems and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Published in AIEE *Transactions*, volume 71, 1952, pages 428–37.

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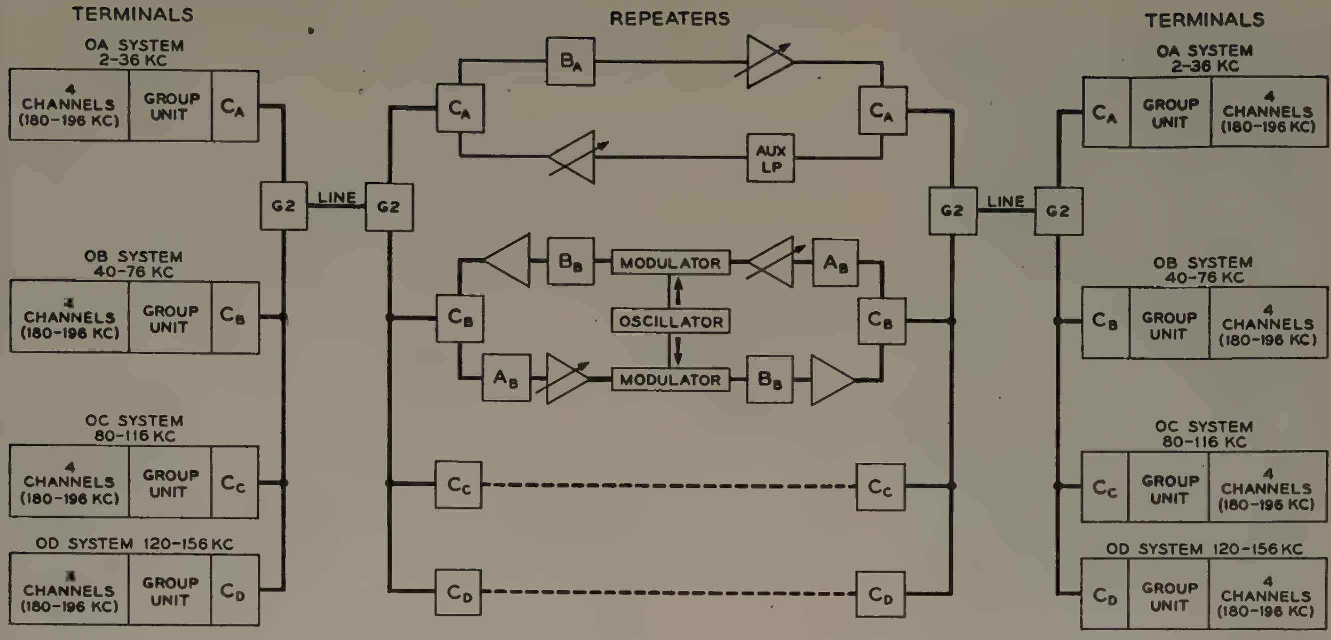

Figure 2. Association of Type O carrier systems

The normal input from the connecting circuit measured at the 4-wire point is at a −16-decibel level. These voice-frequency signals are first compressed by a 2-to-1 compressor in which the volume range of the output signal is one-half the decibel volume range of the input signal. After passing through a low-pass filter to suppress frequencies above 3,100 cycles, the compressed speech is applied to the balanced modulator. The 3,700-cycle supervisory and dialing tone which is turned on and off by the signaling keyer circuit is also introduced at this modulator input. This makes the wanted signal the combination of a voice band 200 to 3,100 cycles plus a 3,700-cycle tone. Considerable carrier suppression is obtained in the modulator balance and two side bands appear in the modulator output. A band-pass filter further attenuates the carrier and suppresses the unwanted side band. The wanted side band is combined with the three side bands from the other three channels and the carriers are re-inserted, to form the 4-channel group output.

The group transmitting unit takes this 4-channel group and group modulates it to the desired line frequency. The lower side band is selected by the modulator filter and then amplified by a broad-band amplifier. By making this amplifier have adequate gain across the band 40 to 160 kc, this transmitting unit can be used in all the *OB*, *OC*, and *OD* systems.

A complete 4-channel terminal is shown in Figure 4. Across the top are the four removable channel units, with

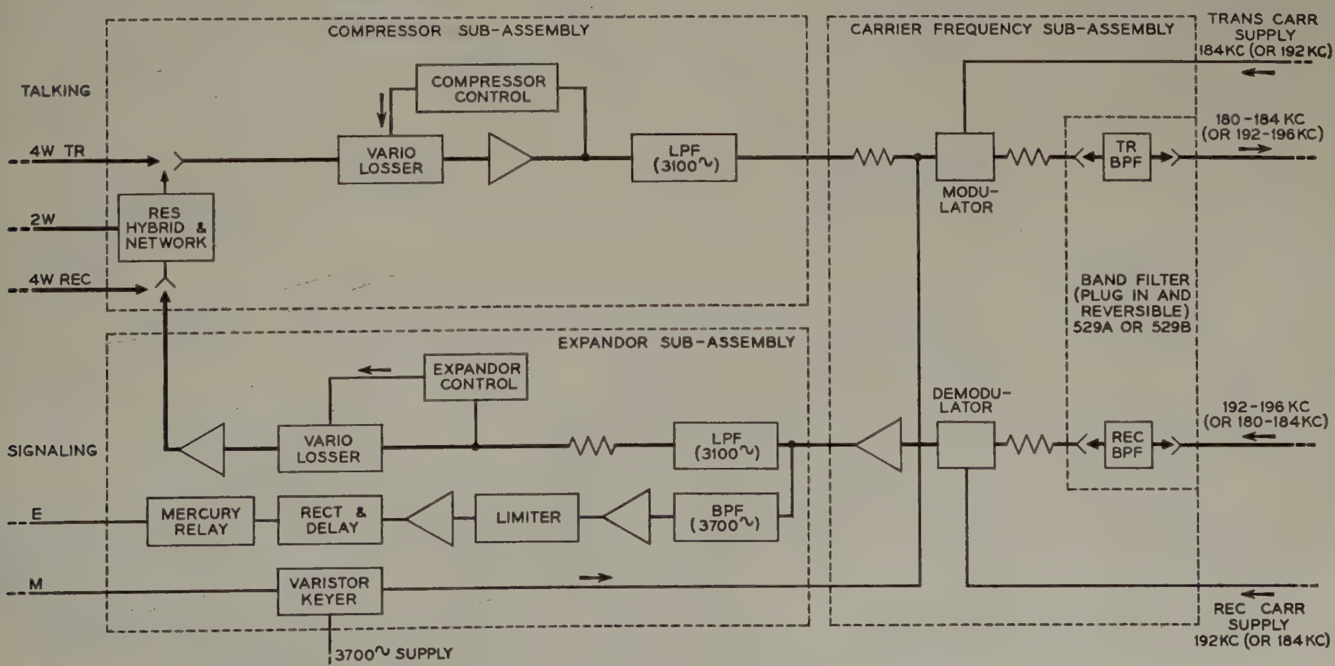

Figure 3. Block diagram of a channel unit

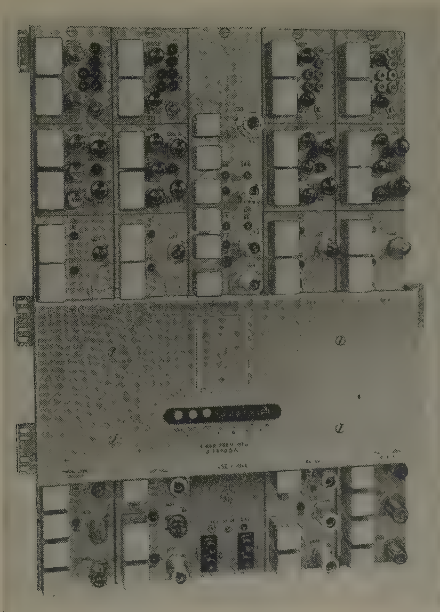

Figure 4. O carrier terminal

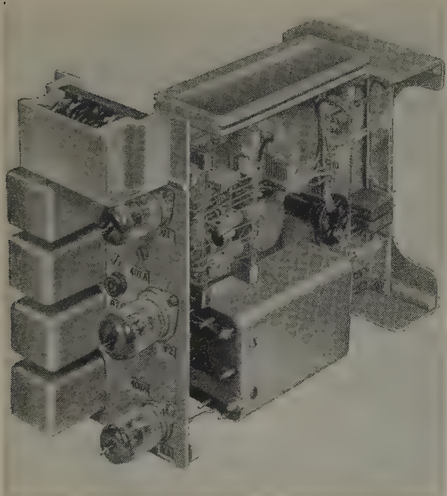

Figure 5. Twin-channel unit. Slide is visible at the top

a group receiving unit in the center position. Across the bottom are five removable units, the two twin-channel units on the outside, the fuse unit in the center, the transmitting group unit on the right of the center, and the group oscillator unit on the left of the center. These ten units are plugged into and supported by a mounting framework, in which the interconnections are made and alarm relays and lamps and terminal punchings for connection of external wiring are furnished.

The unit method of construction facilitates manufacture, operation, and maintenance. The units are guided into place and held securely by a slide in the unit matching a slot in the mounting. A 20-contact plug on the unit engages a socket on the mounting for electric connection. A faceplate, removable by means of four fasteners, holds the units in the frame and covers the relays, wiring, and miscellaneous apparatus. The unit frameworks and the mounting shelves are aluminum die castings which permit the cheap formation of the relatively complicated shapes needed to mount present-day miniature apparatus with efficient use of space, accessibility of parts for manufacture and replacement, and a minimum of brackets, screws, and similar miscellaneous items. Pigtail apparatus is mounted on parallel thermoplastic strips by the same methods as in the Type *N* carrier. These assemblies are shown in Figures 5 and 6.

These units and subassemblies are convenient in the field as they can be removed readily when defective, replaced by spares, and efficiently repaired at central points.

The two twin-channel units in each 4-channel terminal are identical except for the crystal that determines the frequency of the oscillator and the carrier pick-off filter. The oscillator supplies the carrier for 2-channel modulators as well as the reinserted carrier transmitted over the line.

On the receiving side, the 4-channel group comes from the group-receiving unit and is amplified by the twin-channel regulator. The regulation is controlled by the particular carrier that passes through the selective carrier pick-off filter. The output of this regulator is applied to the channel band filters in 2-channel units. Each band filter selects the wanted side band before the signals are demodulated to voice. By maintaining a constant carrier power at the twin-channel unit output, each channel of a twin is regulated just as accurately as if it had an individual regulator. Thus the *O* system obtains performance equivalent to individual channel regulators with half the number of regulators.

The twin-channel unit is shown in Figure 5. The basic die-cast frame and general assembly are essentially the same for this unit, the group-transmitting unit, and the group-oscillator unit.

The group-transmitting unit contains a 2-stage feedback amplifier, with relatively flat transmission from 40 to 160 kc. The total power transmitted is adjustable to permit co-ordination of systems along an open-wire line. If a system is to be connected onto an open-wire line at a point which is not a repeater or terminal point for other systems on the same line, it is necessary to reduce the transmitted level to about the level of the other systems at this point.

There are three independent oscillators in the group-oscillator unit. One supplies the 3,700-cycle signaling tone for the four channels. It has a Weinbridge circuit with a thermistor in the bridge to control the balance. An adjustment is provided to set the magnitude of the signaling tone to the desired value. The other two oscillators are electron-coupled crystal oscillators to supply the group carriers. These carriers group modulate the transmitted signal from the 180- to 196-kc band down to the desired line-frequency band, and group modulate the signals received from the line back up to the 180- to 196-kc band. There are eight different group carriers required for the four systems.

Most of the differences between *OB*, *OC*, and *OD* systems are confined to the group-receiving unit. This unit is generally similar to one-half of the repeater shown in Figure 7, and consists of a basic subassembly and two removable filters. One of these is the directional filter, the other, associated with the group modulator, contains both the receiving group band-pass filter and the auxiliary band-pass filter. The basic subassembly with its 2-stage amplifier, group modulator, and regulator circuit is built to give satisfactory operation for *OB*, *OC*, and *OD*

systems. The particular system is determined by the filters plugged into the basic subassembly. This unit is shown in Figure 6.

All the signals from the line filters are impressed on the input to the group-receiving unit. The desired 16-kc band of frequencies is selected by the directional filter, and passed through the auxiliary band-pass filter to the input of the 2-stage vacuum-tube regulator. The bias on the regulator tubes depends upon the magnitude of the output signal. This bias is obtained from the control amplifier and rectifier circuit. There is sufficient stiffness in this automatic gain control circuit so that for a 40-decibel change in input signal the output will change only 1.5 decibels.

The modulator follows the regulator and operates at practically a fixed level. The desired side-band output of this modulator, 180 to 196 kc, is selected by the receiving group band-pass filter. This band is then amplified in the 2-stage feedback amplifier and transmitted to the twin-channel units.

Noise, from the noise generator in the group-transmitting unit, is inserted at the output of the group modulator. At this point the signals have almost a constant level, hence the noise can be set to mask crosstalk from the line and the magnitude of the noise is practically independent of variations in line loss.

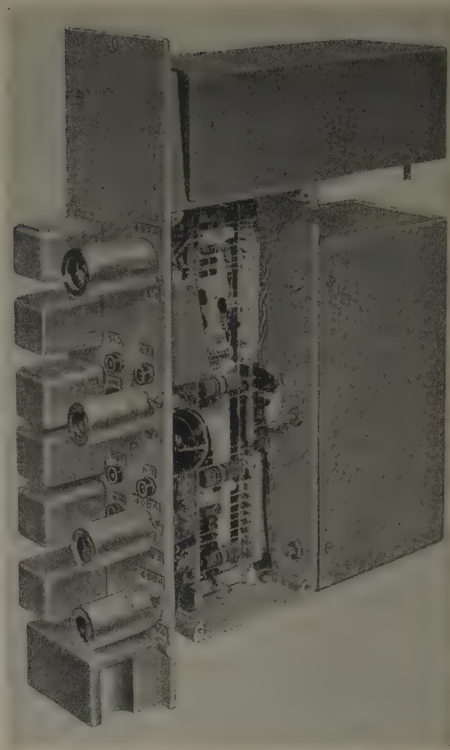

Figure 6. Group-receiving unit or repeater amplifier unit. Plug-in filters are at top and rear

REPEATERS

THE REPEATER of the *OB*, *OC*, and *OD* systems performs four basic functions. It separates out the two groups of frequencies used for the two directions of transmission in its particular system, translates and inverts each incoming group by modulation to the opposite group, amplifies the signals, and automatically regulates the repeater gain to compensate for changes in line loss. The *OA* repeater omits the modulation function since "frogging" is not employed in the *OA* system.

Each *OB*, *OC*, or *OD* repeater includes three units, an east-west (E-W) amplifier unit, a west-east (W-E) amplifier unit, and a repeater oscillator. Figure 7 is a block diagram of a repeater for an *OB* system. Those for the *OC* and *OD* systems are similar, but with different directional and auxiliary filters in the appropriate frequency range and with different oscillator frequencies.

In the systems employing frogging, repeaters along the line are of two types, high-low and low-high, named for their input and output groups. The repeater amplifier units in these two repeater types are identical. To change a repeater from a high-low to a low-high, the directional and the auxiliary filters are rotated 180 degrees and placed back in their mountings. The *OA* repeater is like these but with modulation and the oscillator omitted and amplifiers designed to operate at lower frequencies. The repeater outputs, like the group-transmitting outputs, are adjusted to co-ordinate systems along the line.

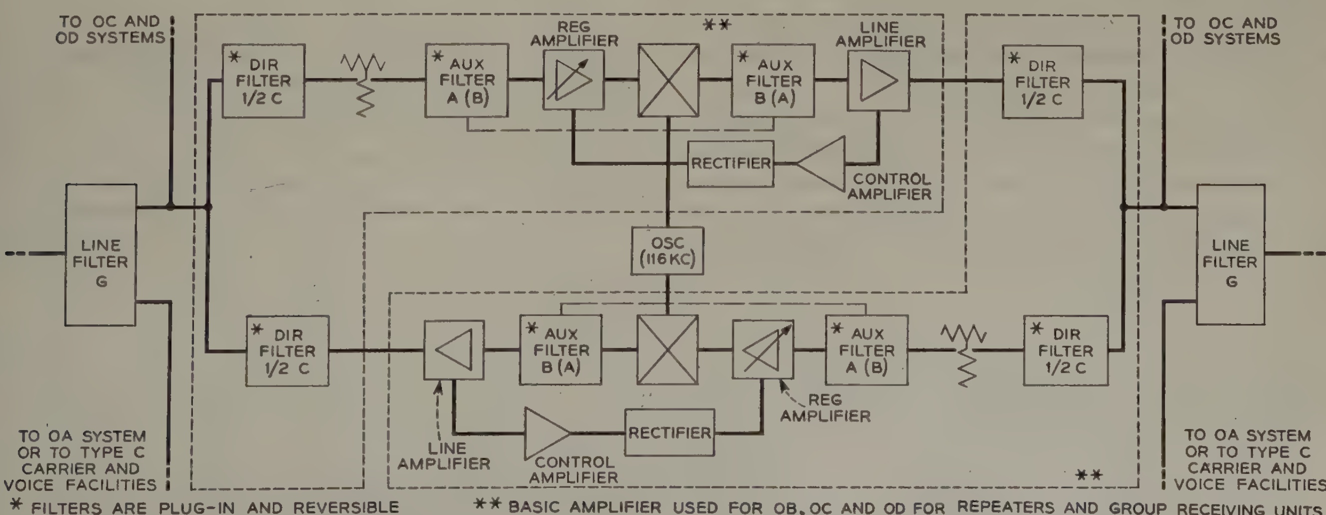

Figure 7. Diagram of OB repeater and line filter

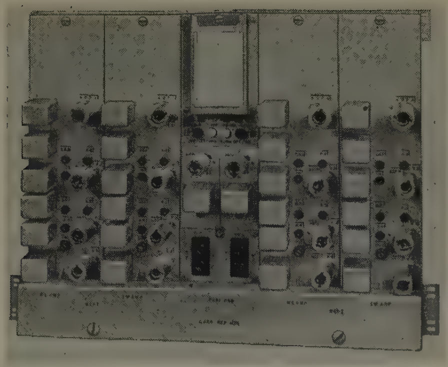

Figure 8. O carrier repeaters. Repeater 1 consists of the two left-hand units and the oscillator at the left center of the fuse panel

The repeater-oscillator circuit is identical with the group-oscillator circuit except for the crystal which determines the frequency and the tuning of the output transformer. Each oscillator is built into a single equipment unit and mounted individually.

Line filters are used to separate *OB*, *OC*, and *OD* systems from a Type *C* system or an *OA* system on the same pair. These line filters are low- and high-pass filters having a cutapart region from 36 to 40 kc. It is more economical to separate *OA* from the other three systems by high- and low-pass filters than continue the band-pass filter method used to separate *OB*, *OC*, and *OD*.

The repeater assembly, shown in Figure 8, is similar to that of the terminal, but five units mounted on one shelf constitute two repeaters. In the picture the two left-hand units are the W-E and E-W repeater-amplifier units of repeater 1, the two right-hand units the corresponding parts of repeater 2, and the center unit a mounting for the two repeater oscillator units, the alarm relays and lamps, and the fuses for the two repeaters. The center unit as well as the repeater-amplifier units are connected to the mounting shelf by plugs and jacks so that all are removable for maintenance and convenient for bench assembly in manufacture. The complete repeater mounting, like the terminal mounting, is shop wired thereby simplifying the installation to that of mounting it on the rack and connecting the external wires to the terminal strip.

At remote locations on light routes, repeaters are mounted in cabinets placed on a line pole or on a crossarm between a line pole and a stub pole. One cabinet contains four repeaters with rectifiers and power control equipment for operation from commercial a-c supply. A similar cabinet when desired contains batteries, dynamotors, and charging equipment for reserve in the event of power failure. A small 24-volt battery with a dynamotor furnishes the 130-volt supply for two repeaters. An alarm is provided over one of the line wires to an attended point to indicate power or fuse failure.

TESTING

As an integral part of any system provision must be made for testing its performance and for trouble location. Pin jacks are mounted in the face of the plug-in units and connected to the circuit at suitable points for testing. These tests are made with a vacuum-tube voltmeter and are designed to show which unit is in trouble. When the bad unit has been located, a spare unit is substituted and the defective unit removed to a convenient repair center.

Under certain conditions more complete tests and adjustments which require access to the interior of the units may be required. For these cases a test stand is provided. A unit may be withdrawn from the mounting on the bay, plugged into the test stand, and connected by a cord to the jack from which it was removed. With the unit effectively connected back into the system either local or over-all system tests can be made on the unit.

FILTERS

The close frequency grouping of *O*-carrier channels is made possible and ecónomical by the combination of:

1. Twin-channel operation with a new dissymmetrical band filter in which a crystal and a ferrite-core inductor are combined to give a flat passband and a discrimination characteristic steep on one side.
2. Group filters which pass a band 16 kc wide with adequate suppression against an adjacent band only 4 kc away with opposite directions of transmission, made practicable by means of ferrite-core inductors.

The channel-band filter is a very compact unit employing a crystal and a ferrite-core inductor. The directional and auxiliary filters have no crystals but contain as many as ten ferrite-core inductors. These inductor cores are a mixture of ferrites providing both high permeability and high resistivity. The ferrite is formed in parts which together form a covered cup with a cylindrical column in the center. The coil is wound in the simplest possible manner on the spindle of a multiple-coil-winding machine and enclosed in the core parts which are then cemented together. The coil is thus enclosed in a ferrite shell with a closed magnetic path so that crosstalk to associated circuits is at a minimum. An inductance variation sufficient for manufacturing adjustment of the filter is obtained by mechanically changing the air gap in the core. A coil occupying less than a $1^1/_2$-inch cube can be made for use at carrier frequencies having a quality factor "Q" well over 500. The winding, formed before assembly, is economical to make and assemble. Ferrite, a very per-

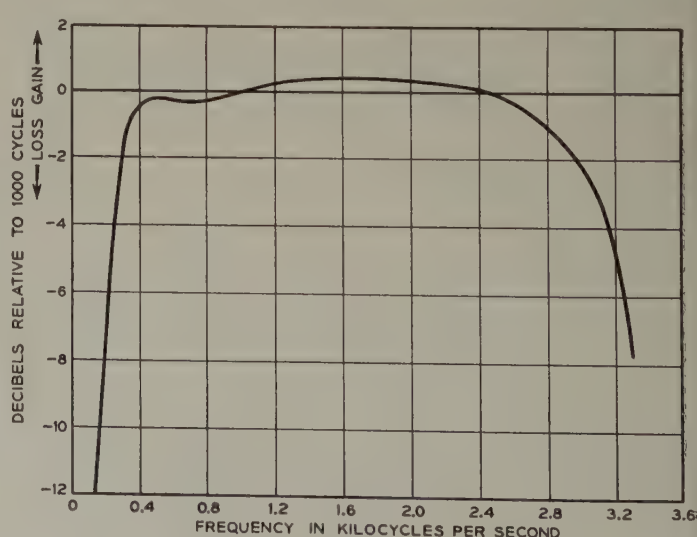

Figure 9. Frequency characteristic of a typical message channel

manent material, is not affected by humidity or subject to aging.

UNIVERSALITY OF PARTS

ONE OBJECTIVE IN DESIGNING the Type *O* system has been to build up the terminals and repeaters for the four systems by flexible combinations of the fewest practicable units and subassemblies. This is of obvious advantage in manufacture and maintenance.

By generating all eight of the 4-channel groups indicated in Figure 1 in the common range of 180 to 196 kc, only four channel-unit types and two twin-channel types are needed for all systems. Each channel unit is composed of three subassemblies. Of these the compressor subassembly and the expandor and signaling subassembly are identical, not only in all *O* systems channels but also in the 12 channels of the Type *N* system. The carrier-frequency subassembly is the same for all *O* channels except for the plug-in channel band filter. This filter is made in two types each serving two of the four channel units by reversal in its socket. There are two types of twin-channel units which differ only in the crystal that determines the oscillator frequency and the pick-off filter that selects the incoming carrier. The twin-channel units are interchanged in position in the terminal-mounting framework to change a high-group-transmitting terminal to a low-group-transmitting terminal.

The group-transmitting unit is universal for all *OB*, *OC*, and *OD* systems. By arranging the filters as plug-in components, the basic subassembly of the group-receiving unit is used in 18 different situations. Six of these are at the terminal: low or high group-receiving unit for the *OB*, *OC*, and *OD* systems. The other 12 situations are at a repeater, a low-high E-W repeater, or a high-low E-W repeater for the *OB*, *OC*, and *OD* systems, and also for the corresponding W-E side of a repeater. The same directional filter is used at terminals and repeaters and is adapted to high- or low-group input by rotating it 180 degrees in its socket. The group and repeater oscillators for the four systems differ only in the crystals. Units for the *OA* system are somewhat different due to its low frequency range.

Identical die castings are used for the terminal and repeater mounting shelves. The castings for the twin-channel units, group-transmitting unit, and group oscillator are the same except for the faces, and all can be cast in the same die by changing the slide which forms the face, a relatively inexpensive arrangement. In this way the total demand for castings is satisfied by relatively few designs, made in large numbers, reducing die cost severalfold.

SYSTEM PERFORMANCE

A MEASURE OF over-all performance of the Type *O* system is shown by the typical characteristics. Figure 9 is a typical over-all frequency characteristic of the message channel. In the normal telephone plant use more than one Type *O* system may be utilized in a particular built-up circuit. A built-up connection that contains a combination of four Type *O* systems in tandem would have the 10-decibel attenuation points, relative to the loss at 1,000 cycles at 250 and 3,000 cycles.

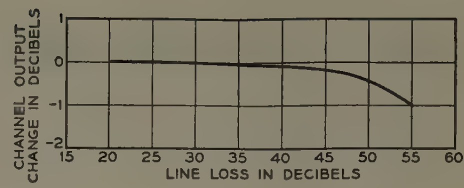

Figure 10. Over-all regulation in a message channel at 1,000 cycles

All carrier systems have a finite limit in the peak power that can be transmitted. Normally an *O* volume-unit (vu) talker will have a peak 10 decibels above the rms value about 1/10 of 1 per cent of the time. This is about the limiting peak for this system.

During normal operation with dry weather conditions along the open-wire line and no "static" fields due to storm conditions, the line and repeater noise is negligible. The background noise, necessary to mask crosstalk from other paralleling systems, is introduced at the receiving terminal and is about 57 decibels below a loud or *O* vu talker. During periods with thunderstorms along the open-wire line, however, the noise on these systems will be primarily "static" as picked up on the open-wire pairs. The increase in noise may be 5 to 15 decibels and on rare occasions even more, dependent upon the severity and location of the storm.

The loss in an individual repeater section depends upon the weather conditions, and may change from a dry-line loss of 13 to a loss of 50 decibels during sleet conditions. Repeater regulation compensates for the change in flat loss. The loss that varies with frequency is compensated in part by frequency frogging and in part by the twin-channel regulator. The over-all change in the 1,000-cycle net loss in a message channel for a 35-decibel change in line loss is shown in Figure 10.

In most carrier systems the extent to which adjacent channels are separated is measured in terms of crosstalk from one channel into the other. One path in the Type *O* system by which energy from channel 1 is able to be heard in channel 2 is through the channel band filters. At the transmitting end the unwanted side band of channel 1 is attenuated by filter 1 to give a clear space for the wanted side band of channel 2. Then at the receiving end the desired speech energy from channel 1 is applied to both channel 1 and channel 2 receiving band filters. In this case, filter 2 must suppress the channel 1 energy from the channel 2 listener. In general the crosstalk due to all sources between channels in a particular Type *O* system is more than 60 decibels below the wanted speech.

A measure of the interchannel crosstalk due to the nonlinearity of the components is the third order modulation products produced in a line repeater. In this instance the line amplifier is not the chief source of this modulation. The ferrite inductors in the group filters, the group modulator, and the regulating amplifier introduce more distortion than the line amplifier. Taking into account the 28-decibel compandor advantage the over-all modulation crosstalk is more than 60 decibels below the normal talkers.

Extensive laboratory tests and field experience with these systems show that good service standards have not been sacrificed for low cost.

Some Fluorinated Liquid Dielectrics

N. M. BASHARA

MANY FLUORINATED LIQUIDS have been made which are of potential interest to electrical engineers. They make available, for the first time, a group of properties not found in any presently used liquid dielectric. They are stable to high temperatures, water and chemical attack, are nonflammable and nonexplosive. Low power factor and low conductivity are characteristic. Advantage also can be taken of the volatile character of these materials. This results from the relatively low range of boiling points (56 to 178 degrees centigrade) found in the compounds which have been studied for electrical uses and the more volatile nature of fluorocarbons in general. This can be put to use in obtaining high vapor densities at relatively low temperatures thereby effecting such improvements as increasing the dielectric strength in the vapor phase. A high natural convection modulus also results which can give improved heat transfer from autoconvection. Good arc-extinguishing properties and low carbon formation from arcing also are found.

The materials studied for electrical uses are essentially carbon-fluorine combinations. The following compounds are representative of the types studied: diperfluorohexylether, triperfluorobutylamine, cyclic ethers, and related compounds with different boiling points. Fluorocarbons have a higher density, higher absolute viscosity, and greater coefficient of expansion than hydrocarbons.

The properties of the compounds studied fall into the following range at 25 degrees centigrade: density (1.7 to 1.9 grams per cubic centimeter), boiling points (56 to 178 degrees centigrade), the liquid range is about 250 degree centigrade, viscosity (0.5 to 3.0 centistokes), surface tension (13 to 16 dynes per centimeter), dielectric constant (1.85 to 1.90), the power factor is less than 0.0005 to the microwave region where an increase is found, resistivity (10^{15} to 10^{17} ohm-centimeters), the dielectric strength averages 40 kv and the refractive indexes are among the lowest known (1.26 to 1.29).

No more than 25 parts per million of water are absorbed at 90-per-cent relative humidity. However, the relative effect on resistivity and dielectric strength appears to be somewhat greater than for hydrocarbon oil despite its higher absorption of 73 parts per million. No occluded water occurs in the fluorinated liquids.

Fluorocarbons have been found to have considerably higher thermal stability than corresponding hydrocarbon and chlorinated structures. Pure samples of a cyclic ether (c-$C_8F_{16}O$) have been tested in a stainless steel autoclave at 300 degrees centigrade to determine the thermal stability. There was no detectable breakdown of the material. Not more than 1 part per million of fluoride was present, which was the lower limit of the analytical method.

These materials do not affect commonly used metals and plastics at 90 degrees centigrade where extensive tests have been made. These liquids have little or no solubility with chlorinated or hydrocarbon solvents and oils.

There is considerably less carbon formation in these liquids than in a hydrocarbon oil or Askarel under arcing. However, acid fluorides which would be harmful to insulation and metals can be produced.

Some toxic products have been found in pyrolysis tests in hot tubes above 500 degrees centigrade. However, no toxic products have been found in arc and corona tests.

All of the materials reviewed here are nonflammable. Carbon tetrafluoride has been proved to be an effective inhibitor of explosions over a considerable range in tests on anesthetics. Isolated tests involving arcing mixtures of 6- and 25-per-cent oxygen in perfluoropropene produced no explosions at room temperature. No explosions have resulted in passing vapors of these and other fluorocarbons through hot tubes up to temperatures of 1,000 degrees centigrade even in the presence of steam.

Large-scale improvement in heat transfer by autoconvection is possible as compared to conventional oils due to high natural convection. Tests showed it is possible to increase power input by 50 to 300 per cent, depending on the liquid used, in the ambient range of 75 to 100 degrees centigrade.

Fluorine would show less thermal ionization than hydrogen. Coupled with the high electron affinity and volatility which promotes formation of eddies, the fluorinated liquids studied showed good arc-quenching properties. This suggests consideration of their use in circuit breakers.

Other properties suggesting specific uses would be high-temperature applications where high thermal stability is required, use of their extremely low surface tensions where good penetration is needed, and taking advantage of low dielectric constants where low interelectrode capacitance must be maintained.

These materials would appear to fill a gap due to the unavailability or undesirability of low boiling hydrocarbon and chlorinated liquids, which would be objected to due to the fire hazard of the hydrocarbons, the solvent action, and toxicity of the chlorinated compounds. While it is obvious there are applications for relatively low boiling materials, certain design changes would be demanded. These liquids would need closed system operation to prevent evaporation and pressurization would be necessary in some cases. Large coefficients of expansion, high densities, and greater relative changes of density and viscosity would have to be tolerated. Their density is not as favorable to the settling out of solid particles. Absorbents probably would be required to neutralize some arc products.

Digest of paper 53-135, "Some Fluorinated Liquid Dielectrics," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Nondestructive Testing of Insulation

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MEMBER AIEE

THE USER OF ELECTRIC APPARATUS is constantly in need of information concerning the condition of insulation. This information, at the present time, is supplied by such tests as insulation resistance, power factor, capacitance, or by more severe tests such as "high-pot." Unfortunately, none of these tests gives a true indication of the "health" of the dielectric, but rather indicate its present condition—a condition that may exist only temporarily and can be corrected by suitable action. It is important, of course, to have this information; however, it is of equal importance in many applications to have an indication of the useful life that can be expected from the dielectric at any time during its use.

The user, as well as the designer, of electric apparatus can predict the minimum useful life of the insulation in such equipment when operated under an assumed set of conditions by referring to appropriate thermal aging curves for the insulation. However, after the equipment has been in operation for a period of time, the past operation will influence the future life and these thermal aging curves are no longer useful. It becomes necessary then to be able to measure some property of the dielectric that is related to this thermal aging process and which takes into consideration the deterioration. During early studies on various insulation measurements the electrical properties revealed a correlation with thermal aging. Further studies were then made on Formex insulated magnet wire to verify these observations on test specimens that reflect the configuration of an electric apparatus.

Measurement of changes in dielectric properties, during aging at a constant temperature, reveals a gradual reduction in capacitance with time due to shrinkage of coil specimen owing to the evaporation of plasticizers. Concurrently, the loss of plasticizer increases the viscosity of the dielectric which reduces the magnitudes of dipolar oscillation and of ion migration. The reduction of molecular and ionic motion reflects a decrease in dielectric loss and an increase in insulation resistance. These variations were found relatively independent of measuring frequency, within the spectrum of 400 to 3,000 cycles per second. However, these coefficients were found to be markedly influenced by the state of humidification.

At the embrittlement point the viscosity of the insulation reaches a maximum and a minimum in dielectric loss is obtained. Using the criterion of minimum dissipation as an index of embrittlement a number of specimen coils were aged, each at a different temperature level ranging from 180 to 260 degrees centigrade. The embrittlement characteristics are presented in Figure 1 together with a life temperature characteristic obtained during an earlier investigation[1] on the same size and type of wire. The aging band represents the first and last failure of 20 specimen coils.

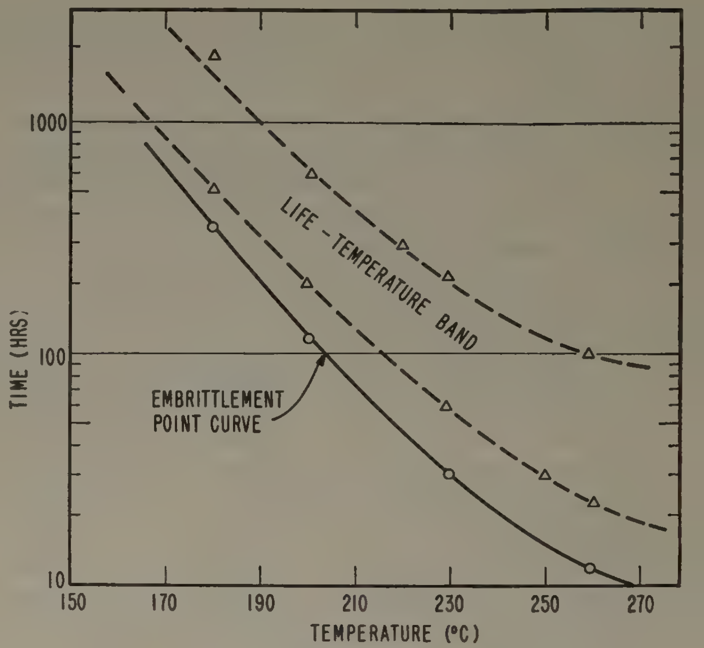

Figure 1. Embrittlement characteristics of Formex

It may be concluded from this investigation that the dielectric properties of Formex insulation undergo a change during thermal aging. This is particularly evident in the dielectric loss and in the insulation resistance. The variations in these values during aging tests can be correlated with the mechanical properties of the materials making it possible to establish the time at which the plasticizer has been removed and embrittlement exists. This point of embrittlement correlates with the minimum point on the normal life temperature curves for Formex insulation.

The usefulness of these changes in dielectric properties during thermal aging in determining the true picture of life remaining in insulation can be evaluated only through further studies of other insulations with dipolar as well as those with nonpolar groups. An investigation of the effects of environment and conditions of contamination is also in order. It is important that studies be made of the change in properties of insulated structures which are composed of two or more dielectrics, as is found in machinery construction. It is expected, too, that further work will reveal the effects of temperature cycling on these dielectric properties; this is particularly desirable information at the higher temperatures.

REFERENCE

1. Aging Characteristics of Electrical Insulation, **R. E. Whipple.** Naval Research Laboratory Report Number *3708* (Washington, D. C.), July 24, 1950.

Digest of paper 53-125, "Nondestructive Testing of Insulation" recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Controllability of High-Pressure High-Temperature Reheat Steam Plants

P. S. DICKEY

AT THE technical session on Systems Engineering of the AIEE Winter General Meeting in February 1949, the general problem of operating steam power plants was thoroughly reviewed. Three phases of operation were discussed as follows:

1. The general problem of fluctuating loads on power systems.[1]
2. Operation of steam turbines on fluctuating loads.[2]
3. Design of boilers and boiler control for fluctuating loads.[3]

In these discussions it was noted that to achieve maximum operating efficiency and minimum maintenance of the steam turbines, the rate of change of load and of temperature should be limited under normal operating conditions. Conservative rates of change which are likely to cause no decrease in turbine efficiency or increase in maintenance are outlined as follows:

1. With a constant throttle temperature, instantaneous load changes of 25 per cent of rated load are permissible.
2. With a constant throttle temperature, the maximum sustained rate of load change is approximately 5 per cent of rated load per minute.
3. Under steady load conditions the maximum temperature change should not exceed 10 degrees per minute.
4. Under emergency conditions total load may be dropped instantaneously.
5. When a unit is running at light load it can be loaded safely as rapidly as dry steam can be supplied in emergencies.

During the discussions the capabilities and limitations of the boiler plant for handling load changes were outlined as follows:

1. Properly designed boilers with wide-range fuel-burning systems can take instantaneous load increases up to 75 per cent of load with no serious effects, though steam-pressure fluctuation may be as much as 10 per cent from normal.
2. Large coal-fired steam boilers are generally limited to instantaneous load swings of less than 50 per cent of rated load due to the limited range of coal burners and the limited response of pulverizers and variable-speed draft fans.
3. For the average plant it is not economical to build steam boilers capable of taking full load increase instantly since the fuel-burning and combustion-air supply systems must be designed for at least 50 per cent overload to take care of the required overfiring during such load increases.
4. Boiler plants of conventional design are capable of following normal sustained load changes within the limits outlined for steam turbines mentioned previously.

The purpose of this article is to review operating experience with steam plants placed in service since 1949 and to review plant design improvements so as to determine whether the controllability of the steam power plant has been materially affected by this operating experience or design change. Steam plants now going into service and plants now in the stage of design or construction show continuation of the following design trends started some time ago:

1. Use of single-boiler–single-turbine units without steam or electric interconnection within the plant.[4]
2. General increase in the capacity of these single-boiler–single-turbine units with sizes of 250,000 kw per unit now being built and larger units being considered.
3. Further increase in steam pressure and steam temperature and general adoption of the reheat cycle on larger units.
4. General adoption of centralized control for one, two, and in some cases as many as four units.

Taking each of these design trends in turn, the following conclusions are reached regarding the effect on controllability of the plant.

SINGLE-BOILER–SINGLE-TURBINE UNITS

ELIMINATION of interconnections and general simplification of main units and auxiliaries has simplified operation and control of the plant. Part *A* of Table I shows the reduction in the number of instruments and controllers per thousand kilowatts of plant capacity resulting from adoption of the single-boiler–single-turbine unit. This tabulation likewise shows that in spite of the decreasing value of the dollar, the actual cost of instrumentation and control has been reduced with the adoption of the single-boiler–single-turbine unit.

UNITS OF LARGER SIZE

IN GENERAL, the capacity of auxiliaries such as pumps, fans, and so forth, has kept in step with the increase in unit size so that no added control complication has been introduced through the use of units of larger size. Pulverizers and burner systems have increased somewhat in complexity with the larger size units but it is believed that this ultimately will be corrected.

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In fact, it appears that with the very large units now proposed there is justification for reconsideration of high-pressure turbine drives which should result in further reduction in the number of auxiliaries and simplification of the control problem.

Section *B* of Table I shows the reduction in the number of instruments and controllers per thousand kilowatt output with increase in unit size and the similar reduction in the cost of this equipment as the unit size increases.

HIGHER PRESSURE AND TEMPERATURE AND REHEAT

THE USE OF higher pressures and temperatures has generally brought on the need for better materials throughout the plant. Not only are high-temperature alloys required for those parts in contact with the high-temperature steam but piping, valves, pumps, and other parts handling high-pressure fluids are kept small to reduce cost and therefore alloys must be used to resist the high velocities of the fluids. In general, the use of smaller, higher speed auxiliaries and auxiliary drives results in improved controllability because of the reduced inertia and more rapid response.

Operating experience with steam plants placed in service since 1949 are reviewed together with plant design improvements since that date. Consideration is given as to whether the controllability of the steam power plant has been affected by this operating experience and design change.

While the use of the reheat cycle has complicated the governing problem on the turbine to some extent and has imposed the need for some additional protective equipment for the reheater surface in the boiler, it has not otherwise adversely affected the controllability or the capability of handling fluctuating loads. If anything, the stability of the boiler plant has been improved with the higher pressure and resulting increase in steam density and with the increased thermal storage due to the increased mass of metal utilized in the high-pressure and high-temperature units.

STEAM-TEMPERATURE CONTROL

WITH THE increase in steam temperature and the adoption of the reheat cycle, control of steam temperature becomes of much greater importance since cycle efficiency is seriously affected by operation below the design steam temperature. Means of control must be devised to maintain design-steam-temperature conditions over a reasonable range of boiler load below the maximum capacity.

Table II shows the increase in proportion of total heat released which is required to superheat and then to reheat the steam with the increased steam pressure and temperature.

With water-cooled furnaces of a size adequate for proper combustion and reduction of gas temperatures to a non-slagging degree, the furnace walls generate a high percentage of the steam and with the higher pressures this percentage increases materially. As furnace wall evaporation is primarily a function of radiant heat absorption, it does not decrease proportionately with the rate of heat liberation in the furnace, so that the percentage of heat available for superheating tends to decrease as the load drops.

Two current boiler designs compensate for this situation in their selection of means for varying the furnace heat absorption for steam-temperature control. The first employs tilting burners to vary the amount of furnace wall surface exposed to the flame radiation. The second employs recirculation of flue gas. Flue gas is withdrawn after passing over most of the convection heat-transfer surfaces and is reintroduced into the boiler furnace at a location and in a manner so as to cut down the furnace heat absorption and thus leave a larger quantity of heat in the gases entering the superheater.

The addition of reheat steam further complicates the control as an additional proportioning control is required to provide the proper distribution of heat to the superheating and reheating surfaces. This is generally done by proportioning dampers in the gas passages which distribute the gas over the reheater and secondary superheater surfaces in accordance with the secondary superheater outlet and reheater outlet steam temperatures. In some cases double furnaces are used with the secondary superheater at the outlet of one furnace and the reheater at the outlet of the other with controls regulating the relative firing rates in the two furnaces

Table I. Instrument Cost Comparison—Typical Central Station Steam Power Plants

Plant	Installation Date	Number of Instruments and Controllers Per 1,000 Kw	Cost of Instruments and Controllers Per 1,000 Kw
A. Multiple Versus Single Boiler Units			
(Type)			
Single turbine, 3 boilers	1939	1.9	$ 910
Single turbine, 2 boilers	1949	1.65	1,222
Single turbine, 1 boiler	1952	1.3	748
B. Small Versus Large Units			
(Size)			
25– 30,000 kw	1952	2.0	$1,300
50– 60,000 kw	1951	1.65	920
100–125,000 kw	1952	1.25	720

Note: Instruments and regulating controls for steam plant only are included in tabulations. No electric instruments, motor or generator controls, or panel costs, are included.

Table II. Distribution of Heat in Superheated Steam

Steam Conditions	Heat Absorption in Steam Generating Units — Heat Required Btu: To Evaporate Water	To Superheat	To Reheat*	Total Superheat Reheat	Percentage Superheat Reheat
400 psi, 750 deg. Fahrenheit	780	185		185	19.2
1,500 psi, 900 deg. Fahrenheit	556	262		262	32.6
1,800 psi, 1,050 deg. Fahrenheit	501	363		363	42.0
2,200 psi, 1,050–1,000 deg. Fahrenheit	424	382	160	542	56.3

* Based on reheater inlet temperature of 400 pounds per square inch, 700 degrees Fahrenheit.

in accordance with the superheat and reheat temperature requirements.

The problems of the steam-temperature-control designer may be summarized as follows:

1. Higher temperatures to be measured and narrower limits of regulation.

2. As a result of a much larger proportion of the heating surface used for superheat or reheat, and the increased mass of metal in the surfaces, long time delays occur in the response of final steam temperature to changes in heat absorption. A time lag of from 4 to 6 minutes in the response of superheater outlet temperature to changes in heat absorption is not uncommon in the modern high-temperature boiler.

3. The high temperature and pressure and high steam velocity requires thermo wells of extra heavy construction to avoid the possibility of failure of the well from vibration. A thermal element lag from 20 to 30 seconds is caused by this necessity of using heavy construction to guard against failure.

4. The steam-temperature control is influenced to a much greater extent by furnace conditions such as slag on furnace walls, flame pattern, excess air, and so forth.

In spite of the problems involved in steam-temperature control and the difficulties proposed by the need for close steam-temperature control over a greater load range, equipment manufacturers have met the demand by novel boiler designs capable of maintaining steam temperatures over the required load range and by improved control systems which overcome the difficulties encountered.

It is believed that the large high-pressure–high-temperature reheat steam generators now being built and proposed will be capable of supplying controlled steam temperatures under fluctuating loads within the limits allowed by the steam-turbine manufacturer.

CENTRALIZED CONTROL

Use of a centralized control system results in the need for some increase in the number of remote controls and instruments required and in some increase in use of protective devices and alarm equipment and some extension to the communication system. However, the resulting improvement in utilization of operating manpower far outweighs any additional cost or complication of control equipment required.

Centralized control requires some refinement in means of remote starting of various plant auxiliaries, but considerable progress already had been made before the unit control center had arrived. There is great interest now in equipment for remote lighting of fuel burners and related equipment under the supervision of television or other indicating and protective equipment.

Development of such remote lighting equipment will remove the obstacle of limited range of boiler operation due to limited burner range and thus actually extend the range over which the boiler will be able to follow the turbine under fluctuating loads.

Much thought is going into the design of control centers for the steam plant in order to improve the efficiency of the operator and eliminate shutdowns or faulty performanc due to operating errors. It is believed that ultimately th use of the centralized control station will improv materially the controllability of the steam plant unde steady and fluctuating loads and, at the same time, minimiz any faulty performance which might be due to human error

Experience, so far, has indicated by the following com ments of operating personnel who have had experienc with power stations equipped with centralized contro rooms:[5]

1. In general, decentralization requires more operator and less control, whereas carefully planned centralizatio of controls combined with proper grouping of importan equipment will require fewer operators and more automati control.

Although the cost of controls will be greater, the over-al annual cost of the job will be less and greater reliabilit of operation will be obtained even though there are con siderably fewer operators.

2. Briefly, centralization requires attention to th following control applications:

(*a*) That all routine matters be delegated to continuou automatic controls.

(*b*) That remote operation be provided for man functions; certainly for all that will be require during transient conditions of the plant.

(*c*) That controls be arranged to minimize possibl errors of operation particularly during periods o stress.

3. The value of closely co-ordinated operation of unit by means of a centralized control is illustrated i nearly every operating abnormality. For example, whe there is an alarm of coal failure to the mill, the electrica operator is immediately alerted and stands by to kee steam pressure up. When operating on block loads an the load supervisor calls for a change, the switchboar operator announces what is to be done as he steps to th panel. The mechanical man will advise him if there is reason to make the change in any manner different fro normal.

These and other experiences indicate that well-designe control centers contribute materially to the controllabilit and general improved operation of steam plants equippe with centralized control rooms.

It is concluded that recent trends in design of stea power plants are in the direction of simplification an improvement in operation and that boiler plants an turbogenerators are equally capable of meeting norma load change requirements.

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The Electric Arc in Argon and Helium

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THE EXACT NATURE OF THE MECHANISM of the high-current electric arc is not yet understood clearly even though the arc has been used and studied for the past century and a half. Much of the difficulty in the interpretation of arc data has been associated with the complexity of the test conditions. An example of this is found in much of the data reported on welding arcs in air. Such arcs are drawn in an atmosphere composed of a mixture of several gases (some of which are very active chemically) with electrodes which are usually of complex metallic and chemical structure.

The investigations described here represent the initial studies in a long-range research project designed to obtain basic information concerning the fundamental properties of arcs between metallic electrodes of high purity in atmospheres of the inert gases, likewise of high purity. It is hoped that data obtained in this manner under carefully controlled laboratory conditions eventually can be synthesized to give a better picture of the arc process.

The arc properties investigated were the general appearance of the arc, its behavior and stability, starting phenomena, and electrical characteristics. Among the electrical characteristics determined were the voltage-current and voltage-arc length relationships and the plasma gradients. The results reported are primarily for argon and helium gases at atmospheric pressure, using tungsten rod electrodes of $^{1}/_{4}$-inch diameter.

All experiments were carried out in a chamber constructed in the shape of a cross from 6-inch-diameter brass pipe. The chamber could be evacuated to better than 1-micron pressure before being filled with gas. Means were provided for visually observing the arc, adjusting the electrode separation, and controlling the gas pressure. Starting of the arc was accomplished by means of a commercial-type high-frequency arc starter. Establishment of a stable arc could not be accomplished unless the power supply was adjusted to give a current of about 70 amperes which would heat the electrodes up to incandescence and apparently initiate thermionic emission from the tungsten cathode.

A system of testing was devised so that data from test to test and day to day could be repeated very closely. At electrode separations less than 0.3 inch the arc in argon consisted of an intense bluish-white flame issuing from the cathode. This type of arc was very stable. As the current was increased, the flame grew in diameter and length. No anode flame was visible at these close separations although the end of the anode electrode was incandescent and quite luminous. At longer separations the anode flame began to appear but it was not as intense in appearance as the cathode flame. The anode flame increased in length with increasing electrode separation while the cathode flame remained relatively stationary in length.

While the arc was burning, the anode electrode became white hot for approximately one inch and the tip appeared to be molten. The cathode electrode was relatively dark except for the bright cathode spot. The anode tip was round and shiney where the tungsten had melted, but the cathode seemed to be coated with a thin deposit of tungsten metal for about $2^{1}/_{2}$ inches from the tip, which presumably was transferred from the anode.

Due to its higher voltage characteristic, the helium arc generates more heat for a given current than the arc in argon. This results in the melting of the electrodes and the formation of droplets producing unstable arc characteristics at lower values of current in the helium arc than in the argon arc. The visible light from the helium arc appears less intense than from argon and the behavior of the flames is more difficult to observe.

The voltage-current characteristics of the argon arc follow the general shape of the usual *V-I* curves for electric arcs. The current range studied was from 10 to 100 amperes with electrode separations ranging up to 1 inch. As the current is increased, the arc voltage decreases, the rate of decrease being large for low currents and small for high currents. For close electrode separations and high currents the arc voltage approaches close to the first resonance potential of argon, which is about 12.5 volts. This seems to be the minimum allowable voltage for the arc in argon under these conditions.

For most electric arcs the arc voltage usually varies linearly with electrode separation, for any constant current. This means that the plasma gradient is uniform throughout the region between the electrodes. For argon the gradient is uniform along the cathode flame and uniform along the anode flame except that the gradients along the two flames are of different magnitude. As an example, the plasma gradient for an arc of 50 amperes current is 16.5 volts per inch between 0.05 and 0.3 inch separation and 7.0 volts per inch for separations between 0.3 and 1.0 inch. The cathode-flame gradient seems to be constant over the current range studied while the anode-flame gradient decreases with increasing current.

The arc in helium does not appear or behave like the arc in argon. The arc voltage in helium is higher than the argon arc voltage for the same current and electrode separation by a factor of 1.7 which is approximately the ratio of the first resonance potentials of the two gases. As of April 1950, the measurements with helium are not as complete as the measurements made with argon. This study is being continued to obtain more complete data for the arc in helium and argon-helium mixtures.

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Off-On Modulated Reversing Clutch Servo Systems

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As cost and reliability are critical factors in aircraft development, it is suggested here that simpler, more sturdy nonlinear electromagnetic servo controls should be considered. They can approximate closely the performance of a proportional type of control by the use of velocity feedback and power gains of up to 50 times in the magnetic servo clutch allow direct operation from the signal-sensing unit.

THE APPLICATION of servomechanisms to aircraft control is largely the result of the last 10 years of aircraft development. Ten years ago many multiple-engine airplanes had no servo systems. In this period, each year has seen an approximate doubling of the planned use of such controls. Today a major portion of the total military airplane cost is invested in servomechanisms of one type or another. The industry is progressing toward an immediate planned future where the pilot will exercise only a monitoring function over the servomechanism which will take off, pilot, and land many aircraft.[1,2]

The early electric and hydraulic servomechanism was required to be supplemented by manually operated mechanical controls. It is doubtful if today's servomechanisms, with their increased complication, have any greater net reliability. Yet, in many cases, the requirement for parallel auxiliary mechanical control has been eliminated.[1] While this elimination sometimes has been unavoidable due to the complicated functions required of present controls, it usually cannot be justified on the basis of improved reliability of present servo controls. Unfortunately, as the complexity of a control problem increases, a point will be reached where a mechanical control is no longer the most reliable. A further increase in requirements can make direct mechanical controls impractical, as, for example, the control of modern jet engines.

The rapid expansion of aircraft servomechanism application has caused air force operation and financial problems of a critical nature. The size and effectiveness of our air force is being limited by the rapid rise in cost of present military aircraft. No small part of this rise in cost is due to the high cost of complicated electronic servo devices. Also, the general failure of electric servo reliability to progress at a rate commensurate with the increased responsibilities now being given aircraft servo control is one of the principal causes of an alarming number of noncombat casualties, noncombat man-hours required for air force operation, and nonoperative airplanes in a typical combat group.[1,2]

Attention should be drawn to an improved type of nonlinear or "on-off" servomechanism. Development of the on-off servomechanism has been by-passed to a large extent because of the complexity of nonlinear mathematical analysis. Electri contact and mechanical prob lems have also discourage this control approach.

Experience with on-of servos, however, has demon strated that relay and mag netic clutch problems can b solved if they are seriousl approached. The resultin device has the possibilities o being less complicated, more rugged and reliable, and o having better acceleration characteristics than proportione controls of similar application.

The off-on servo is distinguished from conventiona servos of this type in that it incorporates velocity feedbac and high-speed servo reversing clutches. Servo powe is obtained from a driving motor operated continuousl in one direction. The servo function is performed b direction of rotation reversing magnetic clutches.

The combined use of velocity feedback and high-spee reversing clutches in an on-off servo elevates its performanc to that comparable with proportional servos while stil retaining the basic simplicity of the on-off control principle For example, single-stage control accuracies of 0.1 per cen of total travel can be obtained. This accuracy result because the low time constants in the servo system as whole provide single-step travels as small as 0.05 per cen of total travel.

A further advantage of an off-on modulated servo i that acceleration performance may be obtained from a all-electric servo which presently can be obtained onl from combined electrohydraulic or electropneumatic sys tems. As an example, electric-actuator acceleration of 50,000 to 100,000 radians per second per second can b obtained. By comparison, conventional hydraulic actua tors have accelerations of about 20,000 radians per secon per second.[3]

OFF-ON MODULATED REVERSING CLUTCH SERVO

IN THE FUNCTIONAL block diagram, Figure 1, the "signa source" for the subject servo may be any of the commo a-c or d-c types. Signal generating and follow-up pair of resistance potentiometers or "selsyn" units may be used Resistance thermometer bridges or variable reluctanc

Full text of paper 52-329, "Consideration of Off-On Modulated Reversing Clutc Servo System," recommended by the AIEE Committee on Air Transportation an approved by the AIEE Committee on Technical Operations for presentation at th AIEE Middle Eastern District Meeting, Toledo, Ohio, October 28–30, 1952. Schedule for publication in AIEE *Transactions*, volume 71, part II, 1952 (January 1953 Section pages 406–10.

dges yielding displacement, acceleration, or strain nals are suitable signal sources.

The "signal-sensing device" in its simplest form may a polarized relay or for a-c signal systems, a ring de- odulator and magnetic amplifier. Due to the power nplifying properties of a magnetic servo clutch, the tput of the signal-sensing device often may be used to ntrol directly the servo clutch power unit. For example, its simplest form a polarized relay signal-sensing device ay control directly a 300-watt output servo clutch.

The block diagram, Figure 1, also shows a "velocity feed- ck" signal generator. This generator provides a velocity oportional negative feedback signal to the sensing vice and is driven by the follow-up action of the servo uator. The velocity feedback signal can be adjusted a value which will cause a controlled series of off-on odulations of the servo-clutch units in a manner to oduce any appropriate deceleration of the actuator as approaches the desired control point. These off-on lses of the servo clutches may be made small enough so at for all practical purposes the servo output is a uniform otion.

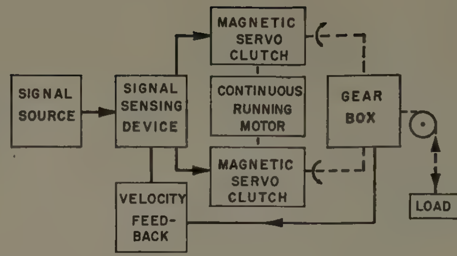
The remaining units in Figure 1 are the two magnetic versing clutches, the continuously running motor, and actuator gearing. These units, together with the dback generator and the follow-up signal source, are embled into the servo actuator.

A power gain of over a million may be reliably obtained m even a simple form of this system such as the polarized ay, clutched servo shown in Figure 2. For example, ypical modern aircraft polarized relay can be made to erate reliably on a 300-microwatt input signal.[4] Such relay equipped with an adequate contact protection twork[5,6] is capable of controlling as much as 10 watts electric power. This amount of power can in turn ntrol a magnetic servo clutch of several hundred watts. e foregoing values are conservative and are not based speculative development of components such as mag- tic powder clutches which may or may not prove to be perior to the simple disk friction clutch using time- oved materials and design. The point is, that these ults can be expected from using the nonspeculative sign of components to be described in more detail in the lowing sections.

MAGNETIC SERVO-CLUTCH POWER UNIT

Several types of servo clutches have been employed in the past in aircraft controls. Most popular of these the initial stage of servo-clutch development was the oportional clutch. In one proportional clutch design, o clutches were geared to drive the output shaft in posite directions. These clutches were maintained in ght engagement in the normal or zero signal position. error signal would cause the increased engagement of e oppositely driving clutch and decrease the engagement the other. This action caused a positive rotating force the output shaft which corrected the position of the uator and thus eliminated the error signal. The object this type of servo clutch was to obtain a torque output oportional to the control signal.

Figure 1. Block diagram of off-on modulated servomechanism



The proportional type of servo clutch has the advantage that it provides a theoretically infinite positioning characteristic necessary for system stability in high-accuracy servos. Also, and not the least of its attractiveness, is that it is considerably easier to treat in a mathematical analysis than the nonlinear on-off clutch. The proportional clutch has the disadvantage, however, that the attempt to maintain proportional control between mechanical drive members involves slippage, severe clutch heat dissipation problems, and low efficiency.

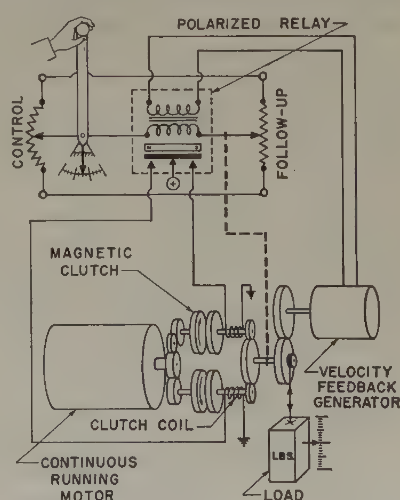
A more direct approach to the problem of servo-clutch design is to admit that the most efficient clutch operation can be obtained with the simple and positive engagement of a dry-disk clutch. Then, if provisions in the servo system are made to off-on modulate this nonlinear control device a close resemblance to the desirable proportional control can be obtained. On the whole, pulsing the clutch in and out for a number of pulses may result in less internal problems and better mechanical efficiency than a clutch which is allowed to slip continuously to accomplish the same purpose.

Another advantage of the on-off servo clutch is that its control accuracy is not a function of the actuator gearing load or the variable load that might be coupled to the actuator output. With a positive action servo clutch, the servo-control accuracy is determined only by the electrical dead space in the sensing element.

The important concept is that a simple and straightforward clutch can be made very effective for servo control. The simplicity afforded by magnetic dry-disk clutches allows a designer to put most of this effort into the details of design which make a clutch reliable instead of having to put the majority of his effort into making some new type of clutch function.

The primary design problem in a dry-disk servo clutch

Figure 2. Basic circuit diagram



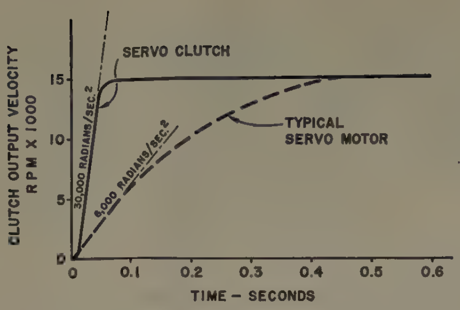


Figure 3. Oscillogram of servo-clutch versus servo-motor acceleration

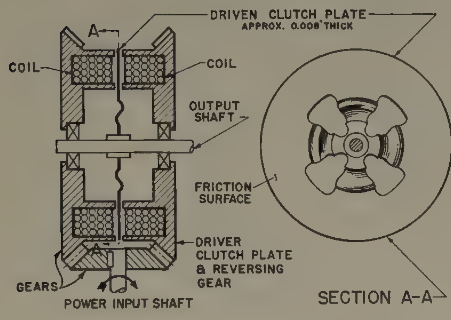


Figure 4. Low-inertia clutch

is controlling the wear that results when the servo load is coupled into the continuously rotating servo motor. The life that may be obtained from a dry-disk clutch is determined by this wear. Clutch failures from excessive wear can result from mechanical failure of the clutch plates or an excessive increase in clutch gap.

In the past, popular clutch materials have been soft metal, cork, or composition material similar to that used in automobile clutches. The real success of the aircraft-type servo clutch, however, has resulted because more durable clutch face materials have been applied.[7] For example, a rugged servo clutch with a life of tens of millions of operations has been obtained by using a case-hardened steel surface operated against a cold-rolled steel surface. Another successful clutch facing has been a polished chrome-plated surface operating against a cold-rolled steel surface. Clutch combinations of stainless steel against case-hardened steel also have proved successful.

One of the most important considerations in a servomechanism design is the speed of response. It is necessary that the power-controlling devices start and stop the mechanism rapidly. With such high-speed operation the servo dynamic error is reduced and stability improved. There is also less chance that the actuator will overshoot and cause mechanical damage at the limits of travel.

High-speed response is difficult to obtain with a typical power-relay and servo-motor type of control because of the inertia of the motor armature. In typical mechanisms it has been demonstrated that in excess of 90 per cent of the actuator inertia is contained in the motor armature.[8] Furthermore, time lags in the power relays required to control the large currents of the servo motor slow down the operation of the servo. A clutch and brake built into the servo motor may assist by removing the motor armature inertia from the stopping cycle problem, but it will not improve the starting characteristic. In any event, the servo-motor time requirements must be added to those the normally required power relay.

When a reversing servo clutch is used with a continuou running motor, however, the inertia of the motor armatu can be moved from the debit to the credit side of the desi ledger. The servo clutch utilizes the stored energy in t continuously running motor armature for high starti acceleration. Actuation time of the servo clutch itself no greater than a typical power relay. For examp a d-c servo clutch requiring 10 watts of power for actuati and capable of controlling a 300-watt aircraft motor c be designed to have an operation and a release time of milliseconds each. This would be a better than avera performance for commercial aircraft relays designed handle the same power.

Comparative acceleration characteristics of a ser clutch and servo motor are shown in Figure 3. In t example the servo clutch accelerates at 30,000 radia per second per second or five times faster than the ser motor.

One of the conflicting design problems in an on- servomechanism is that of providing adequate power f system acceleration while retaining the small pulse tra needed for stability of the system as a whole. In on-off servomechanism it is necessary for stability that t minimum pulse travel or step sensitivity fall within t control dead space established by the sensing elemen It would seem that this requirement in an on-off ser would be defeated by employing a high-acceleration ma netic servo clutch. Such is not the case, however, if t clutch is designed to provide a few milliseconds of starti slip. With this provision it is possible to obtain a st sensitivity equivalent to or better than a servo-mot design, using in both cases the identical motor, actuat and load characteristics. A starting slip characteris is shown in the servo-clutch oscillogram of Figure 3.

Where high accelerations of the servo-clutch system a desired, excellent torque to inertia ratios may be secur with a simple disk clutch as shown in Figure 4. Here thin disk made from magnetic material is cut away the center to provide both the necessary spring action a the flexibility to allow the rim of the disk to engage t driving magnets. Clutch disk travel would be of the ord of 0.005 inch. The flexing support members are show beaded in Figure 4 to allow for angular alignment the disk clutch face with the magnetic driving units. F a servo-clutch power unit typical of the size being describ in the 200- to 400-watt output range, the clutch disk cou be made from material 5 to 8 thousandths of an in thick. Such simple designs require careful mechani refinement but little of the speculative research chara teristic of many current experimental proposals and c be expected to have substantial production cost advantag

The use of magnetic clutches is attractive in servo cont because these devices are efficient transducers of pow from the electrical to the mechanical form. Servo clutc both transform and amplify power in the same operati The efficiency of power conversion may be demonstrat by comparing a typical 300-watt output servo motor t 300-watt output servo clutch. With the servo clut

00 watts of mechanical output power may be controlled with 10 watts of electric input power. A 300-watt output from a servo motor, however, would require approximately 00 watts of controlled input power. In this comparison, therefore, the servo clutch alone shows a power amplification of 30 to 1 and an advantage over the motor of 0 to 1 in the amount of electric power required to control a 300-watt mechanical output.

VELOCITY FEEDBACK

THE APPLICATION OF velocity feedback to off-on clutched controls elevates performance to a level competitive with proportional controls. Velocity feedback is the brakeman on the servo gear train. Its function is to stop the actuator at the position prescribed by the signal-sensing device without overshoot or oscillation. In order to accomplish this job, the velocity feedback first must sense the actuator stopping distance required at any velocity and then signal when to start the stopping operation. In on-off controls, velocity feedback provides a damping characteristic by time modulation of the servo clutch. At a point predetermined by the initial velocity signal, the servo clutch is off-on pulsed to obtain the desired deceleration to the selected stopping point.

A simple type of velocity feedback is proposed as shown in Figure 5. With this method a velocity signal is generated by integrating a series of capacitor pulses obtained when electric contacts are operated. These contacts are opened and closed at a rate proportional to servo velocity. Polarity of the feedback signal is obtained by actuating either one of two sets of contacts according to the direction of the driving cam rotation. The feedback generator described is only one of many types that can be employed in servo controls. The most common is the tachometer generator. This type of feedback source generates a signal proportional to velocity and is the type most often employed.

One point that should be emphasized about applying feedback in off-on servomechanisms is that such feedback should not be used to compensate for slow electromechanical operation. Every effort should be made to purge the basic servomechanism of unnecessary inertias, compliance, and time lags. Then rate feedback should be added as an addition to the basic performance. The approach of making the basic system sound before refining it with velocity feedback has three advantages:

1. The feedback circuit, except for insulation, is reduced from a series to a parallel liability. That is, failure of the velocity feedback unit does not cause servo failure.

2. When velocity feedback is finally added, the system performance improves. For example, the step sensitivity of the servo may be increased many times.

3. Less feedback voltage is required.

The amount of velocity feedback required can be determined from an analysis of the servo stopping characteristic. The velocity feedback signal required is merely the error signal cancelled during the stopping interval. If, for example, the servo at a particular velocity cancels the error signal at a rate of 0.1 volt per millisecond and the stopping operation consumes an effective time of 50 milliseconds, a feedback signal of 5 volts is required for critical damping.

SIGNAL-SENSING DEVICE

TO OBTAIN a type of servomechanism which achieves performance without the sacrifice of simplicity, a simple clutch power unit and feedback generator is suggested. It is appropriate, therefore, to complete this discussion with the simplest possible signal-sensing device—the polarized relay.

A simple contact arm and actuating coil comprising a relay is perhaps the most efficient, lightest, and most stable device for getting power amplifications of the order of 50,000. With these advantages it seems worth while to give the polarized relay a chance by providing at least the same degree of engineering attention to its design and application that would be given to competing electronic and magnetic amplifying devices.

Substantial progress in the design and application of polarized relays to aircraft control has been made recently.[4] Much of the current objection to aircraft use of polarized relays may border on prejudice. Such prejudice has resulted from former attempts to use polarized relay devices not adapted to aircraft environment or to serious misapplication. Under the category of misapplication may be included the use of any sensitive contact-making device without a thorough investigation of the contact problems and the design of appropriate contact protection networks.[5,6]

It is believed that up-to-date relay units with adequate contact protection networks can be applied to aircraft controls in a manner to insure adequate reliability.

CONCLUSIONS

1. The demand for improved reliability in aircraft servomechanism control is increasing at a faster rate than the actual growth of reliability. This reliability factor together with the cost of aircraft servomechanisms is a limiting factor in the size and effectiveness of our air force.

2. Simplification is the first step in improving servo reliability and reducing cost. Electric on-off servo controls are simple and have been based on nonspeculative design which incorporates rugged electromechanical elements.

3. The combined use of feedback and servo clutches in an on-off servo elevates its performance to that obtainable

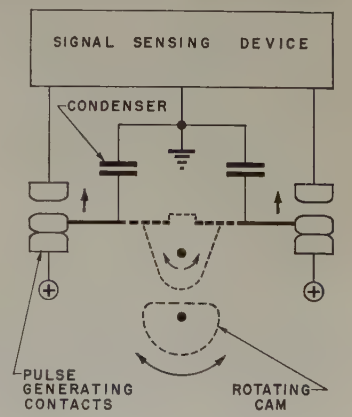


Figure 5. Pulse velocity feedback generator

with continuous control while offering the possibilities of lower cost and weight, greater simplicity and reliability. Single-stage control to 0.1 per cent of full travel is practical.

4. All-electric off-on modulated controls can match response characteristics presently obtainable only with hydraulic or pneumatic controls. Accelerations of 50,000 to 100,000 radians per second per second are obtainable.

5. The off-on modulated type of servo unit is adaptable to large aircraft servo control applications presently using hydraulic or electrohydraulic servos. The subject unit would offer the advantages of all-electric control while avoiding the critical motor starting problem, associated line disturbance, and altitude brush problems of a servo-motor control.

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The Western Chemical Industry's Development

G. L. PARKHURST

The chemical industry's growth in the western states is evaluated on the basis of four criteria: raw materials, utility sources, human resources, and markets. The conclusion is reached that despite certain disadvantages the industry's future is very promising.

THE FAR WEST, which is well known for its expanding population, also has a well-established and rapidly growing chemical industry. The development of a chemical industry in any geographical area depends upon the existence of all of four accessibilities, namely, raw materials, utility sources, human resources, and markets. Without the availability of all of these resources, not only in a physical but also in an economic sense, the area becomes "colonized," that is, it becomes a source of raw materials if they are available, or a market for chemicals, or both, for manufacturers located in distant areas having favorable balances of these four accessibilities.

Fortunately, all of these resources are available in the West. However, it must be recognized that they also are available elsewhere, so that the basic question with regard to the western chemical industry is the rate of expansion contrasted with the national rate of expansion. In order to evaluate this, consider each of the four resources previously mentioned.

With regard to raw material resources, the Western potential is extremely good. Historically, it might be said that the western chemical industry got its start from certain raw materials avai able in the West, particular the production of borax fro the colemanite ores of Dea Valley.

However, it must be reco nized that although a lar number of the needed chem cal raw materials are physically accessible in the West, th are not readily available in an economic sense. In ma instances, the problem is not one of raw materials avail bility, but rather of distances, transportation, or econom methods of recovery from rather low-grade deposits.

Although many areas of the West have been incomplete explored, it is known that the area comprised of the western states is well supplied with a great many r materials important to the chemical industry. The positi of the West compared with the nation as a whole for seve typical minerals is presented in Figure 1. For compar tive purposes, the population of the 11 western states 1950 was estimated at 19.6 million, or 13 per cent of t national total. Compared on this basis, the West sho up rather well for a number of mineral resources.

Salt, soda ash, salt cake, borax, potash, and simil inorganic compounds are plentifully distributed througho the West. Many of these deposits are also economica situated and have been the basis for the inorganic chemi industry in the West. The brines of Searles and Owe Lakes in California are especially notable as starti

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naterials for inorganic chemicals, particularly soda ash nd potash. Salt from sea water by solar evaporation in California is unique to this area so far as the United States s concerned. At the present rate of expansion, production hould soon reach 1,000,000 tons per year.

Petroleum and natural gas have been important factors n the development of both a chemical-consuming industry n the West and also as raw materials to manufacture the hemicals required by the petroleum and other industries. The production of phenol via the cumene route, recently nnounced by several companies, is a striking example of chemical which is not only produced from petroleum, ut also consumed in appreciable volume by the peroleum industry in its refining operations. Estimates nade by the American Gas Association and American Petroleum Institute show proved reserves of crude oil in he western states at 5.8 billion barrels, and natural gas eserves at 25.5 trillion cubic feet for the year 1951. On a er capita basis, this gives the West greater crude oil esources and approximately equal reserves of natural gas, ompared with the nation as a whole. However, in spite f this favorable comparison of natural gas reserves of the West, compared with the nation as a whole, reserves in hose areas of greatest population growth, that is, Caliornia and the Pacific Northwest, are either declining or re virtually nonexistent. This has lead to the bringing in f natural gas from Texas to supply California, and the fforts now being made to supply the Pacific Northwest vith natural gas from Canadian fields. Crude oil is also eing imported into California to meet inflated demands aused in part by the Korean conflict, and a crude oil line s being laid from Alberta to the west coast of the United States.

The West is usually thought of as being deficient in coal, nd this is certainly the case in terms of developed reources. However, in terms of total available mineral eserves, without considering economic and quality factors, he West has more than its proportion of bituminous rades of coal and practically all of the nation's reserves f subbituminous coal. Total coal reserves in the West ave been estimated at over a trillion tons. Due to the istances of these coal deposits from the major consuming reas and the unsuitability of western coals for coking, oal has not played the major part in the industrial deelopment of the West that it has in other parts of the United States. The ready availability of petroleum roducts and cheap hydroelectric power in the areas of reatest population growth undoubtedly has had a rearding effect on the coal industry in the West. The uthor does not consider himself well enough advised on he coal industry to predict whether economic factors will ermit the development of coal as a significant industry n a decade or two or in a longer period. The possible tilization of lignite and subbituminous coals in hydroenation plants for the manufacture of liquid fuels and hemicals, as well as recent developments in low-temperaure carbonization, indicate that the development of a vestern coal industry may come fairly rapidly. In any vent, it is certain to come eventually as petroleum reerves, shale oil reserves, and the more readily available

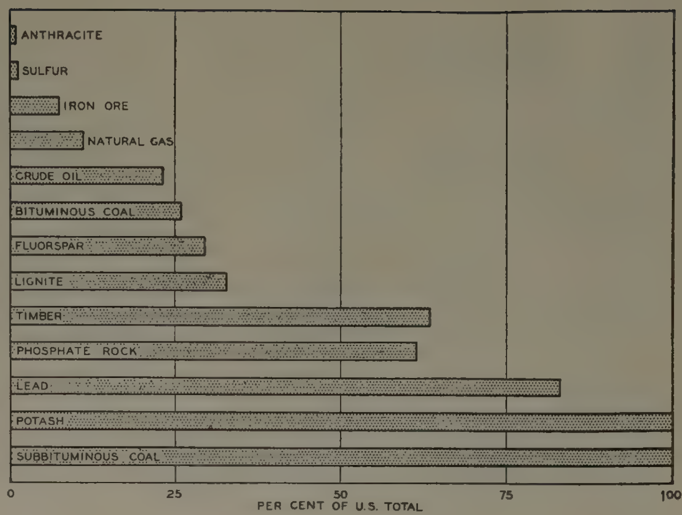

Figure 1. Representative mineral reserves of the 11 western states

and higher grade coal resources of the East and the rest of the world are exhausted. In the meantime the chemical industry must be developed primarily on materials more advantageous than coal.

The phosphate rock situation is very much like that of coal since the western states have the bulk of the reserves, but the East has had, up until recently, almost all of the production, due principally to its greater accessibility. Reserves of commercial rock have been estimated in billions of tons, and lower grade rock would double these estimates at least. Although past production has been relatively small, new plants for the manufacture of electric furnace phosphorus have been announced which will make the West an important supplier of elemental phosphorus to the chemical industry.

Native sulfur deposits are known in several western states, but the ore is of such low grade and located in areas so far removed from consuming centers that economic factors dictate the dependence of the West on Texas sulfur aside from limited western production from natural gas and petroleum refining. The recent shortage of sulfur, which is bound to recur, and new processes for beneficiating these low-grade ores undoubtedly will stimulate production of western sulfur for consumption in areas close to the source, but the major consuming areas along the coast likely will continue to be supplied primarily from Texas, and to an increasing extent from the recovery of elemental sulfur from natural gas and petroleum refining operations.

From the days of the gold rush in California to those of the present expanding iron and steel industry, metals have been important western resources. Although many of these metallic ores are of low quality and located in remote places, smelters are gradually being built throughout the West so that metals can be shipped rather than the less concentrated metal-bearing ores.

The larger timber resources of the northwestern states are extremely important to the Western chemical industry as the production of paper pulp and cellulose has become a large and constantly expanding chemical process industry. In the long-range view, these timber resources will have

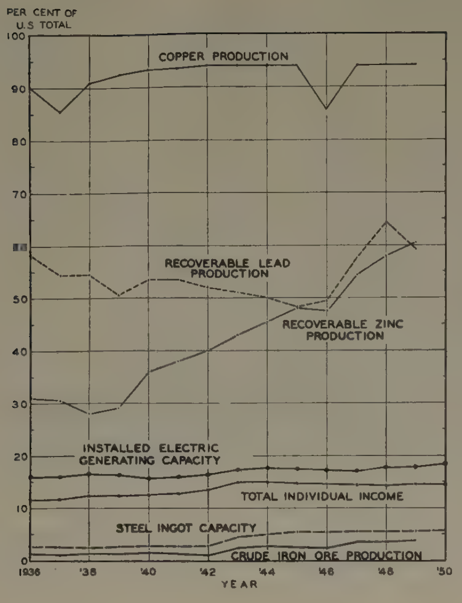

Figure 2. Selected time series: 11 western states as per cent of the United States

much greater importance as a chemical raw material than they do at present since timber, unlike oil or even coal, is a replaceable rather than an irreplaceable natural resource.

In spite of the accessibility of timber resources, synthetic fiber production from cellulose is still lacking in the western area. Since the market for such fiber would be the textile mill and there is no significant textile industry in the West, there is likewise no cellulose fiber industry in the West. However, due to the rapid growth of population, the establishment of a textile industry in the West may not be far off. Such an industry would lead, in turn, to synthetic fiber production, with its attendant requirements for caustic soda, acetic anhydride, carbon bisulfide, and other chemicals.

Compared with the East, the West is still predominantly an agricultural area. Agricultural products are potentially an important source of chemicals, but their importance as food has retarded process developments. Like timber resources, agricultural products are replaceable commodities. The inherent possibilities to be realized from agricultural products were recognized some years ago with the establishment of a Western Regional Laboratory by the United States Department of Agriculture.

The history of the chemical industry is one in which coal replaced wood as a dominant raw material about the middle of the 19th century, and in which oil and gas have replaced coal as the dominant raw materials in recent decades. However, both coal and wood, and to a lesser extent agricultural products, are still vitally important sources of chemicals. In fact, they have grown throughout the years in absolute importance and have fallen behind only in relative importance. Some day the trend is bound to be reversed since the oil and gas resources will be exhausted long before the coal resources, and lumber and agricultural products, being replaceable, should last indefinitely.

Summarizing the West's position with regard to the first required accessibility, raw material resources, the situation is considerably better than that prevailing in the rest of the country taken as a whole. However, chemical plants are not built on the basis of regional averages. They a[re] built on the basis of specific situations. The region[al] availabilities can be at best only a guide to long-ran[ge] trends.

The second of the factors necessary to the establishme[nt] and growth of the chemical industry is the accessibili[ty] of utilities such as water and power. The full utilizati[on] of the first accessibility, raw material resources, cann[ot] proceed without the availability of water and electr[ic] power.

Chemical manufacture requires, in most cases, va[st] quantities of water, not only for process purposes, b[ut] also for the disposition of wastes. The problem of wat[er] in the West, like that of many of the natural resourc[es] mentioned earlier, is not so much one of insufficient qua[n]tity but, rather, one of distribution. Throughout t[he] West the centers of demand for water are seldom locat[ed] in areas of greatest availability, and often a surplus go[es] to waste in one location, while a shortage exists in anothe[r]. This condition has resulted in numerous projects to dive[rt] water from one basin, wherein a surplus exists, to anoth[er] where the demands for water exceed the supply. In spi[te] of such efforts, however, it is often a problem to fi[nd] water at the point which is optimum in terms of the oth[er] three accessibilities. However, this problem is not uniq[ue] in the West, and, in general, is probably no worse than [in] other parts of the country.

The chemical industry, in varying degrees, requir[es] tremendous quantities of energy. In some instance[s], particularly in the electrochemical industry, it is desirab[le] that it be available as electric energy. Although pow[er] shortages have occurred, particularly in the Northwe[st] in recent years, it is believed the long-range power outlo[ok] in the Far West is bright. The rate of growth of install[ed] generating capacity in the West exceeds that of t[he] rest of the United States, as shown by Figure 2. Th[e] chart also shows growth in the production of several of t[he] more important metals, and the growth of individu[al] incomes, as a percentage of the United States totals. [A]s indicated in this figure, the West had, according to t[he]

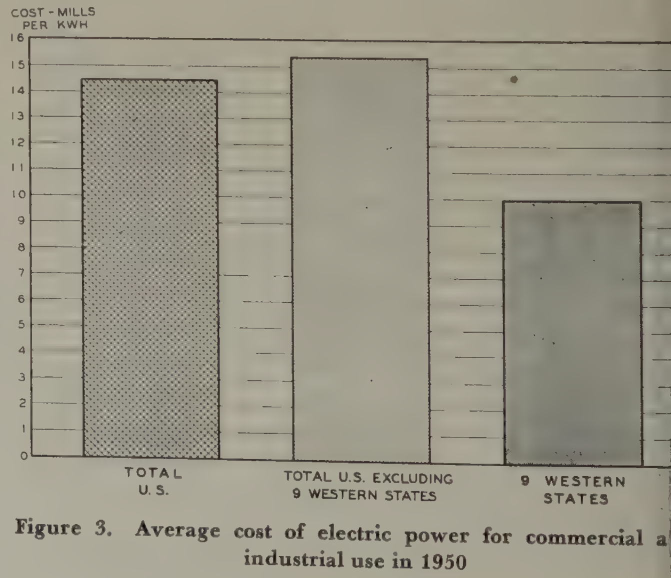

Figure 3. Average cost of electric power for commercial a[nd] industrial use in 1950

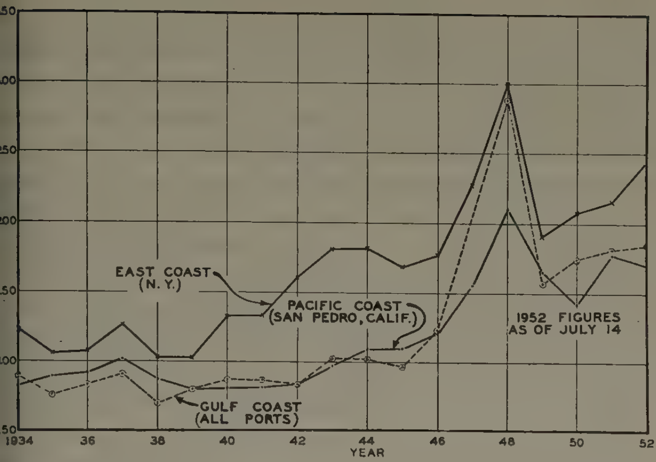

Figure 4. Fuel oil prices: Bunker C fuel

ederal Power Commission in 1950, 18.1 per cent of the nited States installed electric generating capacity. his compares with a population of 13 per cent and dividual income of 14.6 per cent of the national. The vo major power pools in the West—the Northwest Power ool comprising the major utility systems of Oregon, ashington, Idaho, Montana, and Utah, and the Pacific outhwest Power Interchange for California, Arizona, nd Nevada—have a combined generating capacity of million kilowatts compared with about 68.5 million lowatts for the entire nation.

Unlike many other sections of the country, much of the ower generated in the West is hydroelectric. This is articularly true of the Northwest Power Pool, where pproximately 90 per cent of the generating capacity mes from hydro sources. Although more than 50 er cent of the power in the Pacific Southwest Power nterchanges comes from hydro sources, the use of water ower in this area is a declining trend, and new capacity ost likely will be based on steam generation using coal, tural gas, or oil as fuel. In the remaining sections of e United States, excluding these two power pools, hydro- ectric power accounts for only 20 per cent of the total nerating capacity.

This ability to utilize our water resources for hydro- ectric power has given the West an outstanding advantage er the rest of the nation with regard to power costs. his is illustrated by Figure 3. This cost advantage is en more striking in the Northwest, and consequently uch less so, in the Southwest. The Northwest probably ll continue to enjoy this cost advantage since it is estimated at there are 15 to 35 million kilowatts of hydroelectric ower, depending on storage developed, in this area. owever, due to its increasing dependence on steam- nerated power, the Southwest pool probably will see power cost advantage, already small, reduced still rther.

In comparing power costs it must be remembered that erage rates may be somewhat misleading, since any ven plant location problem is influenced by specific tes which may be at considerable variance with the erages. However, even with steam-generated electric power, the West should be no worse off than the East regarding power cost, because of the traditional lower cost of fuel oil on the West Coast compared with other sections of the country. Figure 4 shows this trend of heavy fuel oil prices. Fuel oil has long been cheaper on the West Coast than on the East Coast, and in the long range, it seems probable that the historical relationships will prevail. Thus, the West, in general, is in a good position with regard to the second of the four "accessibilities."

The third of the requisites for the development of a chemical industry is the accessibility of labor, capital, "know-how," and other human resources. Most of the Western centers of population are in a good position with regard to labor resources. The rapidly expanding population provides an adequate labor force of a quality which is believed to be higher, and substantially higher, than in other parts of the country. With the trend towards national uniformity of wage rates in recent years, the high quality of the Western labor force is becoming increasingly important.

Capital and know-how, when the discussion is confined to the domestic scene, are very mobile resources and are hard to confine within geographical bounds. There has been a marked flow of Eastern capital and know-how into the western area throughout the whole history of the West. Figure 5 illustrates one measure of capital accumulation in the West. This chart compares the total deposits of all active banks by geographical area, and illustrates that the West had total deposits which represented, in percentage, nearly the same proportion as does its population. Thus it is apparent that the West is decreasingly dependent upon Eastern capital.

The fourth requirement for establishing, maintaining, or expanding the chemical industry is accessibility to markets. The key consideration in this respect is population, together with the income of that population. Figure 6 shows the historical growth trend of the population in the 11 western states, and California, compared to the United States growth. It is felt that this chart is significant in that it shows that the West has had a population growth trend of 2.5 per cent for over 25 years, and that what some people look upon as a war boom in population is not such at all,

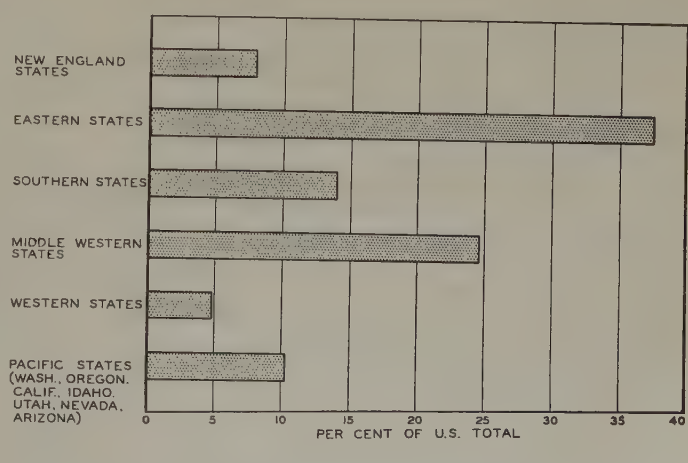

Figure 5. Total deposits in all active United States' banks as of December 31, 1949

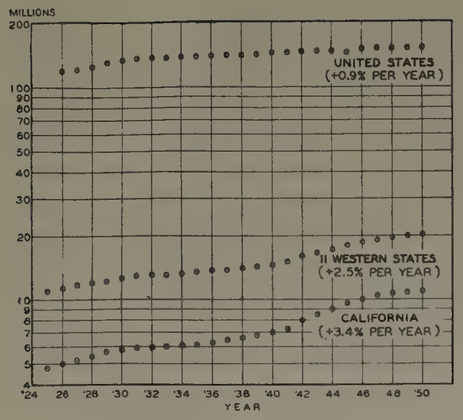

Figure 6. Comparison of Western versus United States population growth

but merely a continuation and exaggeration of a long existing trend. This trend should continue well into the future. As mentioned previously, this Western population amounts to 13 per cent of the national and receives 14.6 per cent of the national income. The potential for consumption of chemicals is, therefore, very promising.

However, in general, chemicals are consumed primarily by industry and agriculture, and only indirectly by people. Thus, the existence of markets for chemicals follows the establishment of basic industry which in turn usually follows population. According to data published in the 1947 census of manufacturers, the 11 western states accounted for only 8.6 per cent of the total value of manufacturing in the United States. Thus, it can be seen that the growth in Western population has not yet been equalled by general industrial growth. Although there are no figures available to compare process industry growth with the general manufacturing figure, it is believed that it is safe to assume that the chemical industry lags general industry, just as general industry lags population.

There is a familiar concept in the chemical industry known as "minimum economic scale of manufacture." This is particularly true of products which can be made by a continuous process utilizing equipment that can be constructed in almost any desired size. Somewhere along the chart of unit costs versus the scale of manufacture, the curve tends to flatten out. On this part of the curve a

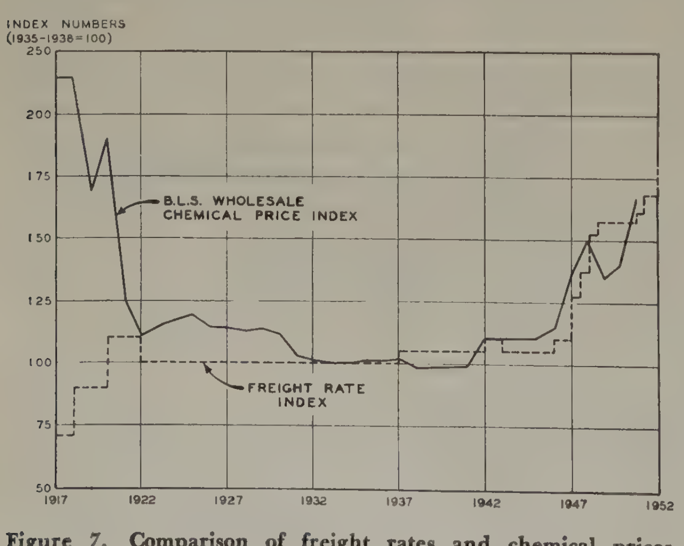

Figure 7. Comparison of freight rates and chemical prices

point is chosen and called the minimum economic scale of manufacture. If markets to consume this minimum quantity do not exist in the West, the excess production must be shipped to Eastern markets, or it becomes uneconomic to manufacture this particular product.

Accessibility to markets is, of course, a relative term. When speaking in terms of domestic markets, accessibility is a matter of freight rates. Since the end of World War II, freight rates have increased sharply, in most cases more rapidly than the increase in the commodity index relating to chemicals. The historical relationship is illustrated in Figure 7.

As this trend towards higher freight rates and higher labor and operating costs continues, (and there is little reason to believe it will be reversed), it becomes increasingly difficult for a western manufacturer to market an appreciable volume from his plant in the East. The high freight rates may work to the disadvantage of the western manufacturer, in spite of the fact that it is just as far from East to West as it is from West to East. The difficulty for the western producer lies in the circumstance that the eastern manufacturer is likely to find the bulk of his market in the eastern United States and only a small part of it on the other side of the continent, whereas the western manufacturer must deliver, in many instances, the major part of his product at a great distance from his plant location. In other words, when freight rates constitute a high proportion of total costs, western industry is encouraged to develop to fill the needs of the population of the West but finds it very difficult to compete with eastern manufacturers if the minimum economic scale of manufacture is high compared with the western demand.

Certain industries are already highly developed in the West, and in many cases consume quantities of certain chemicals in sufficient volume to enable a western producer to sell his entire output from an economic size plant in the western market. Other industries require low-value bulk chemicals, which because of the high transportation cost must be produced in the West.

The nature of the western chemical industry and the market it serves can be summarized by dividing the industry into three groups. The first group includes those chemicals which are manufactured and sold in the West, partly because of the availability of raw material but principally because of their low unit value in relation to transportation costs. It is probably this group, which is illustrated by the heavy chemicals such as sulfuric acid, caustic soda, chlorine, and nitric acid, that has been developed most successfully in the West. A typical example is the development of the sulfuric-acid industry, illustrated by Figure 8. These statistics indicate that in the past decade the West's sulfuric-acid production has remained at a relatively constant percentage of the United States total and almost equals the corresponding percentage for total manufacturing. As pointed out earlier, however, there is a considerable lag in catching up with population growth.

As a very loose generality, the ratio of western production to western consumption of chemical products is an inverse function of product price. As prices increase, there is

higher proportion of chemicals of which there is no western production or else a deficient western production. The western manufacture of chemicals which are sold for dollars per pound, rather than cents per pound, is small. The pharmaceutical and dyestuffs industries, for example, both producing relatively high-priced products, are underdeveloped or almost nonexistent in the West.

The second subdivision of the western chemical industry includes the manufacture of those chemicals used mainly for consumption by well-developed western industry. The major chemical-consuming industries in the West are somewhat different from those of the nation as a whole. For example, the food-processing and surface-coatings industries are probably the major chemical-consuming industries in the West, whereas the most important chemical-consuming industries on a national basis are the rubber and textile industries, the latter being almost nonexistent in the West so far as basic manufacture is concerned. Other industries which are sufficiently developed in the West to be important chemical consumers include the petroleum, agriculture, rubber, mining, pulp and paper, lumber, and soap and detergent industries. Examples of products serving this type of market include phthalic anhydride for the surface-coatings industry and ammonia for the agricultural industry.

The third group of chemicals in this breakdown include those that are manufactured to serve a limited western need, but which, nevertheless, must be sold in large volume on a national or world market because of economic plant-size considerations. In many instances, transportation costs can be greatly reduced by taking advantage of water movement. If chemicals have a reasonably high unit value and are adaptable to movement by tanker, transportation costs often constitute a relatively minor element. When these conditions prevail, a western plant can become economically feasible even though the minimum economic capacity greatly exceeds the size of the western market. In addition, such conditions often enable a plant to be built in excess of current western consumption but in line with anticipated future western demands.

Examples of branches of the Far West's chemical industry which serve a national or world market rather than a purely local one often occur in the petrochemical field; for example, detergent intermediates, para xylene, acetone, and isopropyl alcohol. Examples from other fields include sodium glutamate, methionine, and certain chlorates and perchlorates.

Thus the Western states have all four accessibilities requisite for further rapid growth of the chemical industry. They have an abundance of certain raw materials, but because they are located in areas remote from principal consuming centers, the advantage here is limited. There is a slight advantage in regard to power costs, particularly in the Northwest. The labor force in the West is of adequate size and above average quality, and the availability of local capital is adequate and increasing. Markets in the West, although limited for a great many important chemicals, are expanding, and the freight barrier can work to the advantage of a western producer in these expanding markets.

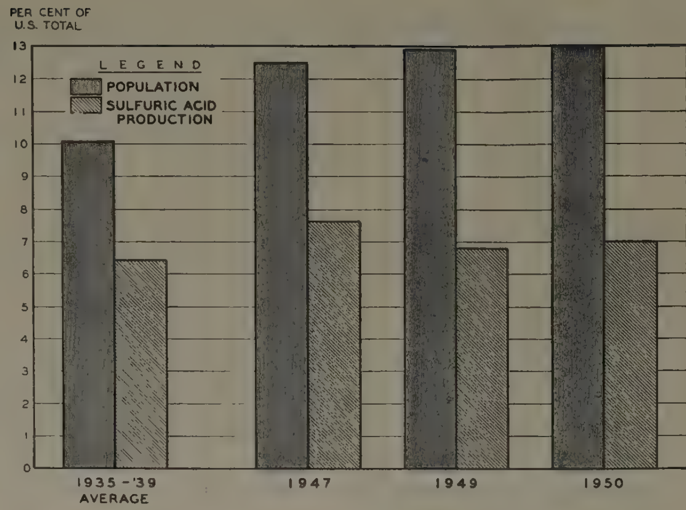

Figure 8. Growth of population and sulfuric-acid production in the West

However, there are also some very serious disadvantages to the growth of the Western chemical industry. The freight barrier, when western markets are small compared to the necessary plant size, works to the disadvantage of the western manufacturer unless it is possible to minimize transportation costs through the use of water movement.

Another problem to be faced in the further development of the western chemical industry is the fact that the new manufacturer in the West must build, with present-day inflated dollars, a plant to compete with Eastern manufacturers having plants built during eras of much lower construction costs. Further, he must compete with manufacturers who have had years of experience in which to develop know-how and reduce production costs.

Consideration of the foregoing analysis of the western chemical industry, and weighing the advantages against the disadvantages and problems, leads to the conclusion that the outlook for further expansion and development of the western chemical industry is excellent. Opportunities for growth now exist, and as western population, industry, and agriculture continue to expand, as it is felt they will, these opportunities will increase with each passing year.

Titanium Dioxide Rectifiers

A new type of rectifier recently developed by the National Bureau of Standards promises to be the first major improvement in metal-oxide rectifiers since their introduction in 1926.

The new rectifiers are made by forming a layer of semiconducting titanium dioxide on a sheet of titanium metal and then electroplating a counterelectrode to the oxide surface. The units can withstand a reverse voltage of about 20 volts per plate and have good properties at elevated temperatures. The plate is made of 1/2-inch-square commercial titanium metal sheet, 0.020 inch thick.

Sudden Gas Pressure Relay for Transformers

R. L. BEAN H. L. COLE
MEMBER AIEE

NUMEROUS PROTECTIVE DEVICES HAVE been developed for and applied to power transformers. A new addition to this field is the sudden-pressure relay (SPR).

This relay is designed to operate on sudden changes in gas pressure in the gas space of a gas-cushioned liquid-insulated transformer. Its operation depends on the rate of pressure increase within the transformer. It is unaffected by static pressures or the slower changes in pressure which are normal to transformer operation. On occurrence of a fault inside the transformer which will produce a moderate rate of increase in pressure, the relay closes contacts which will sound an alarm or trip a circuit breaker.

The breakdown of transformer oil or other insulating liquid due to electric arcs results in the evolution of a gas. The amount of gas formed is a function of the arc energy, and the rate of pressure increase is determined by this and the volume of gas above the liquid.

The SPR relay consists of a pressure-sensitive device, a seal-in relay, equalizer, and test plug all mounted in a pressure-tight case.

The heart of the relay is the pressure-sensitive device made up of a diaphragm and a single-pole, double-throw microswitch. It will operate on a differential in pressure across the diaphragm of about 1/3 pound per square inch.

The operation of the pressure-sensitive device is governed by the equalizer. This is a noncorrosive pipe plug with a small hole through it forming an opening between the transformer gas space and the relay case. Normal transformer operation over its entire pressure range can be maintain with equal protection by virtue of this device. The sma opening acts to throttle any pressure change of a modera or rapid rate of increase so as to effect a pressure differe tial. It is this pressure differential acting on the pressu device which initiates relay operation.

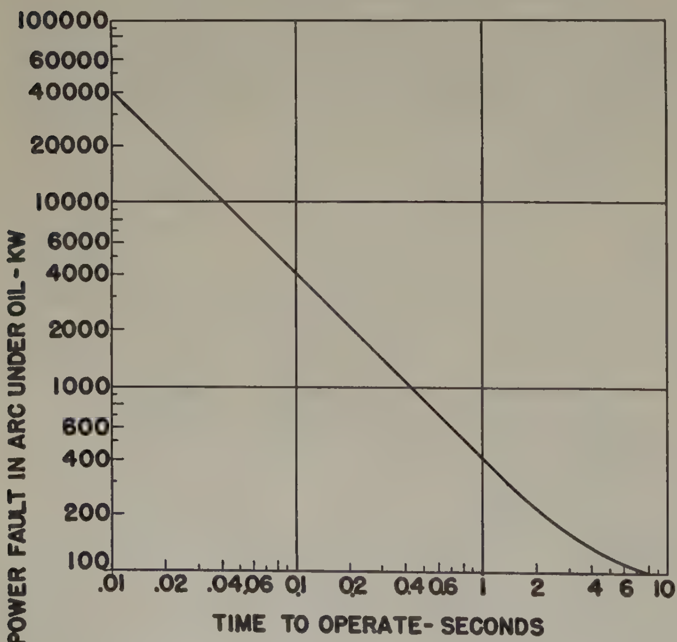

Figure 1. Calculated performance of the SPR relay on a 10,000-kva transformer with 100,000-cubic-inch gas space

A differential pressure so produced is transient in natu When caused by a low-current arc it may last for only a fe cycles. The pressure-sensitive device will respond a close the alarm and trip circuits under such conditions.

The seal-in relay will close in 1/4 cycle. It is electrica interlocked when it closes so that the alarm contacts a sealed upon operation.

A test plug in the case permits a simple test of the rel while the transformer is in service. When the transform is operating at static pressure above 1/2 pound per squa inch, the plug may be removed and the relay will opera The relay may be reset easily after the plug is replaced.

Resetting of the relay is accomplished by a manually o erated momentary off switch which accompanies the rela

The SPR relay has been subjected to many tests whi show that the relay performs as the engineers predicte The results of these tests may be summed up as follows:

Its operation does not depend on the static pressure the transformer tank but rather on the rate of rise in pr sure above the static operating pressure of the transform regardless of whether that pressure be positive or negati The relay will respond to a rate of rise in pressure as l as 1/4 pound per square inch per second provided t total increase in pressure is at least 1/3 pound per squa inch.

Disturbances which produce rates of rise of 10 to pounds per square inch per second cause the relay to ope ate in 2 or 3 cycles, and for rates of 40 pounds per squa inch per second it will operate in 1/2 cycle. It will n operate, however, on changes in pressure common to no mal transformer operation. Disturbances external to t transformer whether mechanical or electrical will not ope ate the relay unless the transformer is damaged itself.

What this really means to transformer protection can described best by Figure 1. Although this is a calc lated curve, it has been checked favorably against te in which arcs were produced under oil.

The completion of the SPR relay has given industry new protective device which will sound an alarm and t the circuit, upon occurrence of a fault inside of the tra former. Compared with other pressure devices, it is mu more sensitive to small faults, and much quicker to op ate when a large fault occurs.

Digest of paper 53-134, "A Sudden Gas Pressure Relay for Transformer Protectio recommended by the AIEE Committee on Transformers and approved by the A Committee on Technical Operations for presentation at the AIEE Winter General M ing, New York, N. Y., January 19–23, 1953. Scheduled for publication in A *Transactions*, volume 72, 1953.

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Electrical Properties of the Inorganic Papers

T. D. CALLINAN

A discussion of the electrical properties of both the naturally occurring paper-forming inorganic materials and the synthetically prepared fine inorganic fibers is followed by a presentation of various applications.

THE DEMAND FOR reliability in electric equipment under severe :onditions of temperature ınd weather has necessitated he development of papers ıaving insulating qualities ınd thermal stabilities far above those found in rope and vood-pulp products.

Two approaches to the solution of the problem have een investigated, see Table I. One involves the bene-iciation and modification of naturally occurring paper-orming inorganic materials, and the other, the preparation, ynthetically, of fine inorganic fibers suitable for paper naking. In the first category are asbestos, bentonite, ınd mica, while glass fiber, ceramic fiber, and silica fiber ccur in the latter.

The work of Hauser and Reed[1] indicated that the urification of natural film-forming inorganic bodies, such ıs bentonite clay, resulted in nonflammable electrical nsulants. While these films, because of their continuity, ossessed dielectric strengths superior to those of the better arnishes, unfortunately they lacked the toughness, flexi-ility, and tear strength requisite for handling in wire ınd cable capsans. Some commercial exploitation of hese films in the capacitor field was undertaken by Rohm ınd Haas under the trade name of "Diaplex"; this product s being developed by Aircraft Marine Products Corpora-ion.

ASBESTOS PAPER

RECOGNIZING THE DEFICIENCY of the films, Walters[2] developed the bentonite-modified asbestos papers alled "Terratex," while Quinn's work[3] resulted in the pres-ntly available commercial "Quinterra" and "Quinorgo." Modifications of these types[4,5] including "Novabestos" ıave been disclosed. The asbestos papers found their mmediate use in the air-cooled transformers and reactors rated for operation at elevated temperatures and under conditions where the liquid-cooled counterpart is unsuitable.

In the early stages of the work, the apparent solution of the problem of a thermally stable dielectric paper rested on the availability of high-grade magnetite-free chrysotile asbestos. World War II demonstrated glaringly the absolute need for (*a*) techniques for purifying the asbestos of Canada, (*b*) reopening the Arizona deposits, or (*c*) finding other inorganic dielectrics based on materials indigenous to the United States.

MICA PAPER

AT THE SAME TIME that the shortage of electrical-grade asbestos was alarming the logistics experts, the mica problem had become acute. Although many thought the problem to be a shortage of mica as was the case with asbestos, actually, the shortage was one of labor supply. Accurately evaluating this, Heyman began his studies on mechanically splitting mica; his work resulted in "Integrated Mica."[6] Bardet's work[7] on the chemical pulping of mica has resulted in mica paper preparable on a modified Fourdrinier machine.[8] To a paper maker the two developments correspond to mechanical versus chemical pulping. These latter products are available in the United States now under the trade names of "Samica"[9] and "Mica Mat."[10]

SYNTHETIC FIBER PAPERS

CHEMICALLY, the natural and synthetic paper-making materials for inorganic papers are best distinguished as shown in Table II. It can be seen that the items on the left are the glass formers or high-melting items, silica melting at 1,710 and corundum (alumina) at 2,000 degrees centigrade. On the right, the network modifiers are indicated. These substances tend to lower the melting point of the material, necessary in the case of economic glass-fiber spinning, but undesirable in the case of the

evised text of an article recommended for publication by the AIEE Subcommittee on ielectrics of the AIEE Committee on Basic Sciences.

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Table I. Inorganic Paper of Manufacturers

Natural Base			Synthetic Base		
Asbestos	Bentonite	Mica	Glass Fiber	Ceramic Fiber	Silica Fiber
ohns Manville	Aircraft Marine Products Corporation	Integrated Mica Corporation	Hurlbut Paper Company	National Bureau of Standards	National Bureau of Standards
aybestos-Manhattan		Samica Corporation	American Machine and Foundry		
eneral Electric		General Electric	National Bureau of Standards		

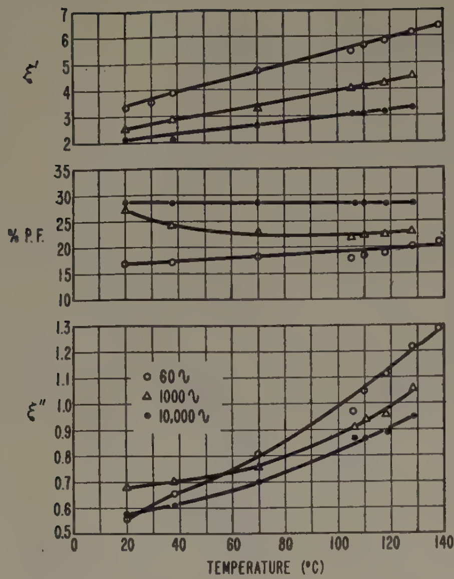

Figure 1. Electrical properties of asbestos paper

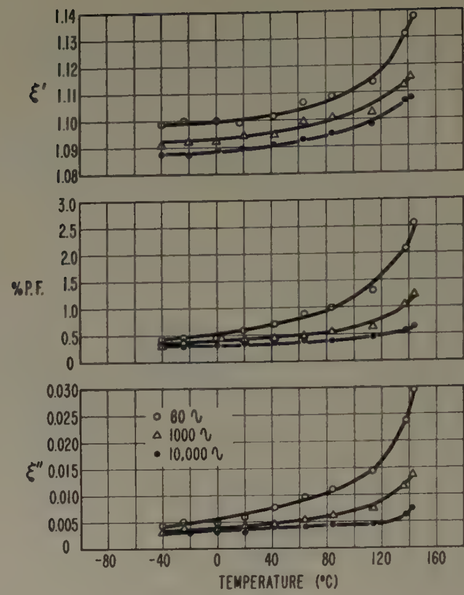

Figure 4. Electr cal properties c ceramic-fiber ber tonite-clay pape

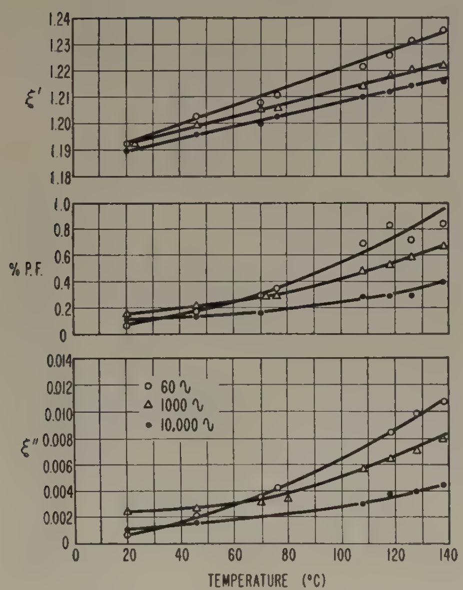

Figure 2. Electrical properties of mica paper

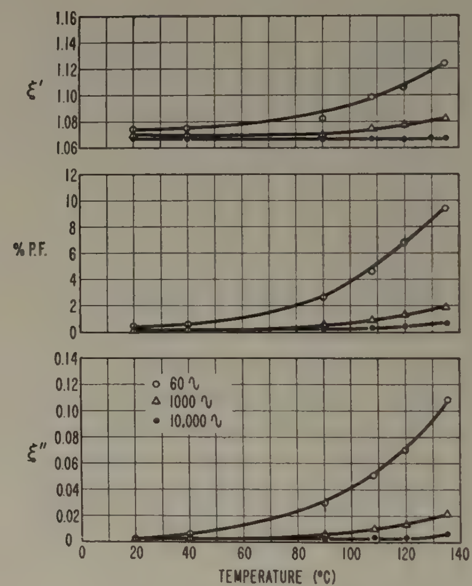

Figure 5. Electr cal properties c hydrous silica fiber paper

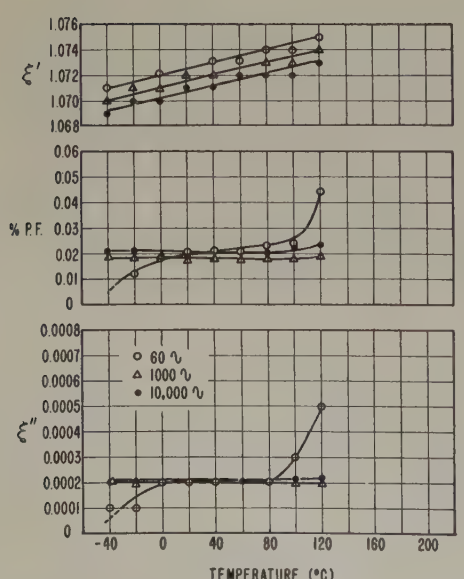

Figure 3. Electrical properties of glass-fiber paper

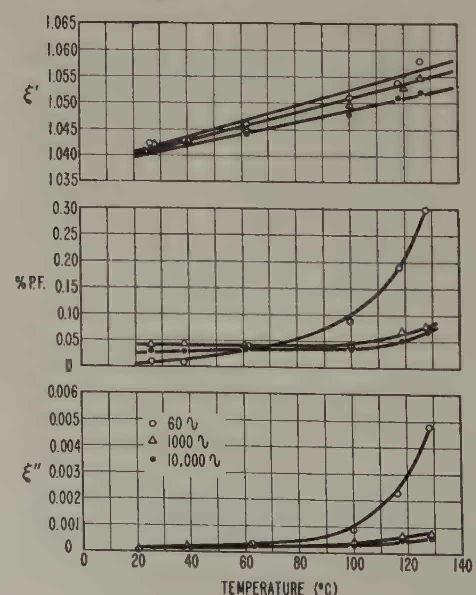

Figure 6. Elect cal properties anhydrous silic fiber paper

natural hydrous bodies—asbestos, mica, and bentonite.

The exploitation of the synthetic inorganic fibers as paper-making pulps[11] has increased appreciably during the last year[12] due to the commercial availability of glass fibers from Glass Fibers, Inc., and Owens-Corning Fiberglas Corporation; of ceramic fibers from the Carborundum Company; and of silica fibers from the H. I. Thompson Company and Glass Fibers, Inc.

Since all three types of fibers are available commercially in diameters of 2 microns, and in the cases of glass and silica as low as 0.2 micron, the fibers may be handled as a water-dispersed paper stock in commercial equipment. Fibers of greater diameters tend to settle in the paper-making system and are not commercially feasible at this time. Again, the fine fibers permit the production of a paper of greater fiber density, and consequently of greater mechanical strength. At the present time, the papers are approximately 1/10 the density of the material from which the fibers were made. While it is apparent that the finer the diameter the stronger the product produced, due to increased packing factor the problem of spinning fibers which are both fine and long tends to put a practical limit on the finest diameter commercially suitable for exploitation. At present fibers having diameters of 0.2 micron are, on the average, 50 microns in length. Apparently the quality of the melts from which these fibers are blown can be changed to produce certain engineering improvements in the ratio of length to diameter. Also, as a temporary solution, the admixture of the fibers with filler clays such as bentonite, or with organic binders such as phenolics, melamines, neoprenes, and water-soluble cellulosates, has resulted in the development of useful items.

The glass fiber art has reached the stage where the producer can ship the glass pulp in bales for processing. Similarly, the silica fiber is available as a bulk item. "Fiberfrax" is still in the developmental stage and must be sent through a refining system to remove the shot and slubs which form in any method of producing rock wool. Glass fibers, in general, are free from such slivers because of the melt spinning techniques employed. Silica fiber, which is produced by leaching and recovering glass fiber, is similarly free from such shot. In general, Vortraps or sand traps will clean a shot-laden pulp without difficulty.

The Hurlbut Paper Company markets glass-fiber paper. The National Bureau of Standards has made paper from all three synthetic inorganic fibers.

ELECTRICAL PROPERTIES

UNLESS A BINDER IS EMPLOYED, all the inorganic papers are weak and fragile; their commercial exploitation depends at this time on impregnating them with selected resins, varnishes, and sizes. Depending on the impregnant employed, the electrical qualities of items from different suppliers differ. In order to permit necessary design characteristics to be calculated, the dielectric constant, per cent power factor, and dielectric loss factor of Vortrapped cleaned Canadian asbestos, see Figure 1; mica paper, see Figure 2; and machine-made glass fiber, see Figure 3; ceramic fiber, see Figure 4; and silica-fiber paper (both hydrous, see Figure 5, and anhydrous, see Figure 6) are given. None of these papers contains binders.

Table II. Chemistry of the Inorganic Papers

Inorganic Papers	Network Formers	Network Modifiers
Silica	SiO_2	
Ceramic	SiO_2 . . . Al_2O_3	
Bentonite	SiO_2 . . . Al_2O_3	H_2O . . . Na_2O
Mica	SiO_2 . . . Al_2O_3	H_2O . . . K_2O
Asbestos	SiO_2	H_2O . . . MgO
Glass	SiO_2 . . . Al_2O_3 . . . B_2O_3	K_2O . . . Na_2O . . . MgO . . . CaO

The constants were determined by the Endicott technique consisting of drying each sample in a test cell in a heated vacuum-desiccated chamber and testing the paper in place when completely dry and after dry air had been introduced. Hence the relative humidity at test is 0 per cent. The dielectric constant and loss factor of an impregnated paper may be calculated from these data, if the electrical constants and the volume ratios are known. Due to the porosity of each sheet, approximately 90-per-cent air, neither dielectric strength nor insulation resistance measurements were made.

APPLICATIONS

WHEN SUITABLY TREATED with a binder, inorganic papers may be employed satisfactorily in a variety of applications. Some are employed as mechanical filters in gas masks, while others are used in air-cleaning equipment for stack gases or infected areas. The utilization of certain inorganic papers as wire insulation in dry-type transformers and reactors is a commercial reality. Generators and motors now use considerable quantities of inorganic papers for slot-armour and segment insulation. The high absorbency of the inorganic papers indicate their usefulness in such diverse fields as paper-base laminates and paper chromatography.

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Transient Measurements of Feedback Control Systems

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APPLICATION OF FEEDBACK CONTROL systems has become so extensive that much engineering effort is spent in their evaluation and maintenance.

Transient analysis involves introduction of a step function to a system and determination of system response with respect to time which gives information concerning speed of response and tendency of the system towards oscillation. Transient measurement can save valuble time when tests on a production basis or routine maintenance checks are necessary.

Requirements of the measuring means are necessarily determined by characteristics of the feedback control systems to be studied. Present systems have error detectors, amplifiers, and power converters of widely varying form so that even those systems which have the same functional application are not necessarily composed of the same mechanical, hydraulic, or electrical components. In addition to this physical diversity, there exists a large variation in output power level and response time-scale. Instrumentation to examine transient response should be adaptable to all such systems without bothersome alteration either to the system or the measuring means. The instrument must be capable of introducing a step function of proper magnitude to any such system and must be able to permit observation of system response without distortion.

Consideration of various applications indicates that response duration may be expected to lie within a range from 15 milliseconds to 3 seconds. Here, response duration is defined as the interval elapsing between initiation of the step function and the time the system obtains a condition of steady-state minimum error. Some systems exhibit small variation in response upon repeated application of identical step inputs, which may be attributed to such nonlinearities as stiction friction and back-lash. For this reason it is desirable that the measuring instrument introduce a repetitive train of step-function inputs to the system to provide the operator with a continuous flow of information. A further requirement is imposed by carrier feedback control systems. In order that response be repetitive it is necessary that initiation occur at a fixed magnitude of carrier phase. This implies that the response duration for carrier systems must contain an integral number of cycles of the carrier.

Generation of the square wave for this instrument is obtained from an oscillator in which the necessary feedback is furnished by a magnetic recording drum. Square-wave half-period is determined by drum speed and head spacing. A voltage corresponding to system response applied to the vertical amplifier of a cathode-ray oscillo scope equipped with long persistance screen and suitab sweep-synchronizing signals are supplied. A coincidenc circuit is provided for carrier systems which functions t alter the square-wave half-period established by the osci lator so that the time point of initiation of the transier occurs at a fixed phase of carrier frequency.

Determination of response magnitude as a function time obtained directly from the response pattern woul be in error. To obtain greater accuracy a null metho of comparing complex response waveforms with a cal brated d-c potential is used. Time measurement is ac complished through the use of a second track on th magnetic recording drum. As the angular position of th pickup head of the second track is varied, the synchronizin signal for the oscilloscope is proportionately shifted in tim with respect to the square wave. Thus, a desired point o the transient curve may be displaced horizontally to co incide with sweep initiation. A calibrated d-c referenc voltage from a precision potentiometer then is added to th response signal to displace the trace vertically until th initial portion, which corresponds to the measured poir in time, is in correspondence with a zero magnitude base lin established on alternate square-wave half cycles. Th setting of the calibrated potentiometer is a measure of re sponse magnitude at the desired time. In this manner, point-by-point tabulation of response magnitude as a func tion of time is obtained which is independent of swee nonlinearity or amplifier drift and distortion.

The instrument includes a visual method of phas sensitive detection to permit examination of a desire phase component of the carrier signal. This is accom plished by pulse brightening the oscilloscope beam by phasable carrier voltage. The resultant response patter is a series of points disposed horizontally at intervals corre ponding to carrier period and vertically at magnitud corresponding to the instantaneous value of response the selected phase.

A single sweep circuit provides for photographic re cording of the response of a system in optimum adjustmen so that this pattern may be used at a later time as a guic for adjustment of a similar system.

The instrument developed is sufficiently versatile to allo determination of transient response of a large number feedback control systems with a minimum of alteratio to either the instrument or the system. Transient chara teristics may be examined for repeated application of step function and the effect of system adjustment observe The instrument is self-contained; it provides the necessa step-function inputs and permits either photography quantitative determination of response magnitude as function of time.

Digest of paper 53-101, "Transient Measurements of Feedback Control Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Optimum Design of Permanent Magnets

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THE ANALYTICAL APPROACH to the optimum design of permanent magnets which are subjected to demagnetizing effects is complicated by the fact that the slope of the minor hysteresis loops is not constant throughout the range of the main demagnetization curve. For some permanent-magnet materials, therefore, the slope variations are small, and a constant slope may be assumed without causing objectionable error to the design. For other materials however, as for instance the presently most widely used alloys of Alnico V and Alnico VI, the slope may vary considerably and hence will not justify such an assumption.

Samples of an Alnico V material have shown maximum differences of 220 per cent between minimum and maximum slope. The volume of the optimum magnet, based on the assumption of constant slope values in the same range, would vary up to approximately 35 per cent, for practical interesting degrees of demagnetization. The influence of the slope of the minor hysteresis loops has thus proved to be of importance for the design economy. Permanent-magnet design methods, therefore, when applied to materials with large slope variations, require careful consideration of this fact.

Extensive investigations conducted by the Signal Corps Engineering Laboratories have uncovered valuable results, which greatly assist in overcoming the difficulties associated with the variation of the slope of the minor hysteresis loops. It was found that optimum designs are being obtained exclusively for minor loops which originate from a limited zone of the main demagnetization curve, while minor loops originating from other portions of the curve are insignificant for optimum designs.

For all permanent-magnet materials investigated as of the present, including all alnico grades, it was found in particular, that the zone always has its upper limit at the point of maximum energy product. The location of the lower border depends on the material and the considered range of demagnetization and may be anywhere between the point of maximum energy product and the intersection of the main demagnetization curve with the abscissa axis. This result is illustrated for Alnico V, VI, and XII in Figure 1. The left portion of the diagram contains the main demagnetization curves, magnetic induction B versus demagnetizing force H, of the three materials; the point of maximum energy product is denoted by B_o. The right portion of the diagram shows the relations between the magnetic induction B_{or} at the origin of the minor loops leading to optimum designs and the degree of demagnetization k and c corresponding to demagnetization by increase of external reluctance, case (A), and applied magnetomotive force, case (B), respectively. The zones at the main demagnetization curves, related to the B_{or} values in the considered range of demagnetization degrees between 0 and 10, are marked. Alnico V has a very small zone for both cases (A) and (B). Alnico VI and XII have

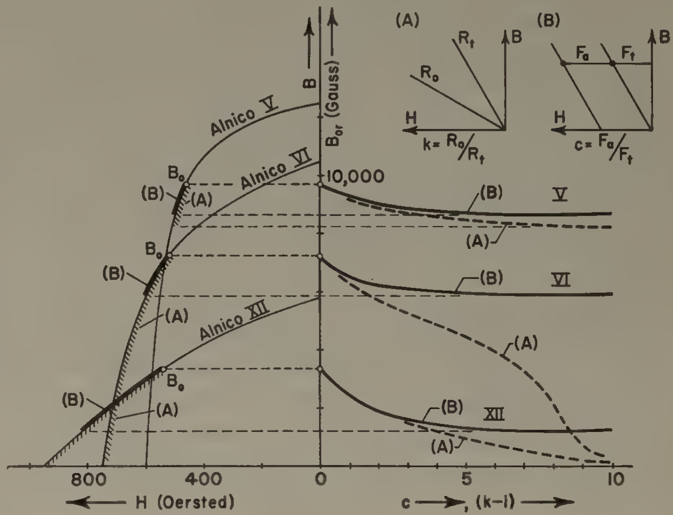

Figure 1. Diagram of relations between demagnetizing degree k and c respectively, and magnetic induction B_{or} at the origin of the minor loops for optimum designs

small zones for case (B), but extend their zone from $B_{or} = B_o$ to $B_{or} = 0$, for case (A).

The discovery of the limited zones permits the introduction of average values of the slope of the minor loops, computed from the values of these zones, into design relations. With regard to the fact that the major variations of the slopes occur, as a rule, in the disregarded part of the demagnetization curve above B_o, average values are obtained which differ little from actual maximum and minimum values within the zone. The use of these average slope values offers, therefore, a means for a more accurate analytical treatment of problems in the design of permanent magnets.

Based on these results new design relations for the optimum design have been derived which make possible the calculation of convenient design charts for any permanent-magnet material. Differing from previous approaches, a hypothetical, ideal magnet was assumed and correction factors have been determined to account for the deviations in the characteristics of the ideal and the actual magnet material.

Digest of paper 53-152, "Optimum Design of Permanent Magnets," recommended by the AIEE Committees on Basic Sciences and Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Economical Utilization of Electric Power Equipment

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The extensive research undertaken and the data obtained, which have resulted in a substantial saving in investment in electric power equipment throughout the Chicago system, are presented in some detail.

IN RECENT YEARS, the constantly increasing cost of additions to electric plant has brought into sharp focus the importance of obtaining optimum utilization of equipment. In order to achieve this, it is necessary to determine the load capabilities inherent in the various pieces of equipment, from the prime movers to the users' service leads; to obtain co-ordination of capabilities of the various pieces of equipment connected in series in each installation; and to make provision for carrying loads approaching the capabilities as closely as is feasible and economical. These requirements hold for emergency operating conditions as well as for normal operation.

The load capabilities for a given piece of apparatus are a function of its inherent characteristics, mainly thermal, as well as of conditions pertaining to its installation and operation. The capabilities should be determined on the basis of obtaining

1. Reasonably reliable service for each type of equipment involved.
2. A life equal at least to the expected time when obsolescence or system changes will result in abandonment of such equipment.

An outstanding characteristic of the electricity-supply business is the high investment required, which has been approximately $4.00 per $1.00 of annual revenue. Since 1939, the unit costs of installations of electric power equipment for utilities, including necessary structures, have doubled. Various steps have been taken in planning systems and designing installations to reduce unit costs. In general, however, the most effective measure for combating high costs is to take full advantage of load capabilities. The immediate result of such action is that much load growth may be handled by existing equipment.

Load capabilities are a function of allowable temperatures for the current-carrying parts of the equipment. The records of technical organizations indicate that Commonwealth Edison Company engineers have been active through their researches and co-operation with others for over 30 years in investigating problems relating to the effect of temperatures upon the performance of various kinds of equipment. This research frequently has resulted in establishing increased temperatures for normal operation and, more importantly, new and still higher allowable temperatures for emergency operation of most apparatus.

Increases in load capabilities of some underground cables were established in a sma[ll] way starting some 20 yea[rs] ago. Early in 1937, loa[d] capabilities for emergenc[y] operation, in addition t[o] those for normal operatio[n] were introduced for all un[-]derground cables in Chicago, Ill. Starting later, the sam[e] practices were adopted at various times for other syste[m] equipment. The result of all this activity in the past 1[…] years for the Commonwealth Edison Company has bee[n] substantial savings in investment in plant.

Manufacturers build equipment to meet industr[y] standards on requirements, including those relating t[o] temperatures. In addition, they have been supplyin[g] detailed thermal data for equipment, including informa[-]tion on insulation and current-carrying parts, which ar[e] useful in load capability work. Many utilities now hav[e] planned programs to increase loading of transformers an[d] of some other equipment.

THE PROBLEM

IN ORDER to obtain the fullest utilization of equipment studies of the following three factors are required:

1. Relation between temperature and/or temperatur[e] rise, and life.
2. The load characteristics of the installation.
3. Relation between the loading characteristics an[d] resultant temperature or temperature rise.

With regard to the first factor, it is necessary to establis[h] the maximum temperatures and/or temperature rises t[o] which the equipment could be subjected safely for th[e] durations and frequencies expected for emergency opera[-]tion, as well as to establish the maximum temperatur[e] values permissible for normal operation. In some case[s] such as the coils in a long generator armature or th[e] commercially-pure lead sheath of a large undergroun[d] cable that is subjected to repeated small bends in manhole[s] the temperature range produced by daily load change[s] may set the limits on allowable loadings.

In actual service, equipment usually is operated at [or] near its normal load capability for only a small fraction [of] its life. Some of the reasons are as follows: operatio[n] usually starts with a moderate load in order to allow fo[r]

Condensed text of paper **52-260**, "Economical Utilization of Electric Power Equipment[…] recommended by the AIEE Committee on System Engineering and approved by t[he] AIEE Committee on Technical Operations for presentation at the AIEE Participati[on] in Centennial of Engineering, Chicago, Ill., September 10–12, 1952, and represent[ed] at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Pu[b]lished in AIEE *Transactions*, volume 72, part III, April 1953, pages 203–20.

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load growth before additional equipment needs to be installed; the loads vary appreciably during each season of the year; during the heavy-load period of a given season, there may be considerable variation between the daily peaks; and there are the possible effects of changing business conditions and of system changes to cause decreases in loads for some periods. In addition, the actual ambients generally are appreciably less than those assumed in calculating the capabilities, with the result that the permissible maximum temperatures are rarely reached. All of the points given here apply also to the possible loads to which the equipment may be subjected during emergency operation.

The life of equipment is affected not only by the limits for normal and for emergency operation, but in most cases by the accumulative effects of the actual daily loading. This fact, as well as others, makes it necessary to establish permissible temperature limits for loading in relation to the temperatures for the expected average loading, in order that maximum over-all satisfactory performance is obtained for the life of the equipment.

This leads to the second requirement, that is, a study of the load characteristics of the installation, including an estimate of the frequency and duration of emergency operations. This study should include such factors as load growth, diversities in loading, load fluctuations, nature of load cycles and load factors, and the relation of actual amperes carried by a piece of equipment to the kilowatts or kilovolt-amperes delivered. A high maximum load may be permitted for those special cases where the equipment is required to carry only a fraction of the load for a large majority of the time. On the other hand, a daily fluctuation between a moderate load and no load may have a greater effect on cable sheath life or on armature insulation than a heavy steady base load will have on these factors.

Finally, it is necessary to know the relation between loading and the actual temperatures reached. A knowledge of this relation becomes more important as the temperature limits increase. A careful study must be made of all the variables affecting the temperature or temperature range of the equipment, such as the following: rate of temperature increase with time over a period of hours, electrical and thermal proximity effects, effects of adjacent equipment, effects of enclosures, the total thermal path for such cases as cables in floors and armature conductors in a hydrogen-cooled generator, and the relation of the hottest-spot conductor temperature in a transformer, generator, underground cable, motor, and so forth to the measurable temperatures.

Once the temperature limits and the load characteristics of an installation have been established, a study of the relation between load and temperature permits the establishment of high allowable loadings without incorporating unduly large margins of safety in installations and consequent extra costs, and without fear of exceeding the permissible temperatures.

In this activity on determining load capabilities, it is assumed, of course, that a reasonable program of field inspections and maintenance is pursued.

LOADING PROBLEMS

The loading problems vary both as to types of load that may be carried during the life of the equipment and as to the required degree of reliability. With a single transformer and associated secondary mains, the problem is generally to determine how much current may be carried safely during the yearly heavy-load periods. There may be cases where the load will be relatively high for a short period each year, such as for a distribution transformer serving a residential neighborhood which has loading at Christmas time or for a public building that holds special events for a few days a year. It has been found feasible to make the capabilities in such instances higher than the usual normal figures.

The second type of problem, which is probably the most important one, is the determination of emergency load capabilities. In many or most cases, it is these capabilities which determine the firm capacity and whether or not additional equipment has to be installed to serve load growth.

Emergency loading in most cases means loading an installation of two or more parallel circuits, consisting of apparatus or lines, or both, during periods of one or a few days when one of the circuits has failed. When the number of lines or transformers, or the like in parallel is just two, it obviously would be desirable to have an emergency load capability equal to twice the normal load capability. When the number of elements in parallel is three, then the desired ratio is 1.5. However, the emergency load capability for durations of several hours or a few days is never as high as twice the normal load capability, and rarely even 1.5 times the normal. Thus, for a few circuits in parallel, the firm capacity is a function of the emergency load capability.

The third type of loading is generally associated with bulk-power-supply systems. The problem on turbine-generators is to determine the allowable loadings, especially during unusual peak load periods or during unusual system conditions due to forced outages of capacity. For the turbine-generator, the emergency capability of the turbine when operated with wide-open throttle, if permissible, may be 10 to 30 per cent higher than its nameplate rating. The problem for transformers and other equipment connected to a generating unit is obviously similar to that outlined for the turbine-generators. Another special case is the loading of tie lines between stations at 10 to 30 per cent above normal for a few hours to a week due to turbine-generator outages or other system troubles. The firm capacity of the bulk-power-supply system is a function of the allowable loadings during emergency conditions.

Due to conditions as outlined in the two previous paragraphs, much interest has developed in determining allowable temperatures for emergency operation. In these various types of loading problems, the frequency and duration of emergencies or planned special high loads vary greatly. A few examples follow:

1. For a group of seven 12-kv lines in parallel consisting of 20 miles of underground cable, records of rates of failure

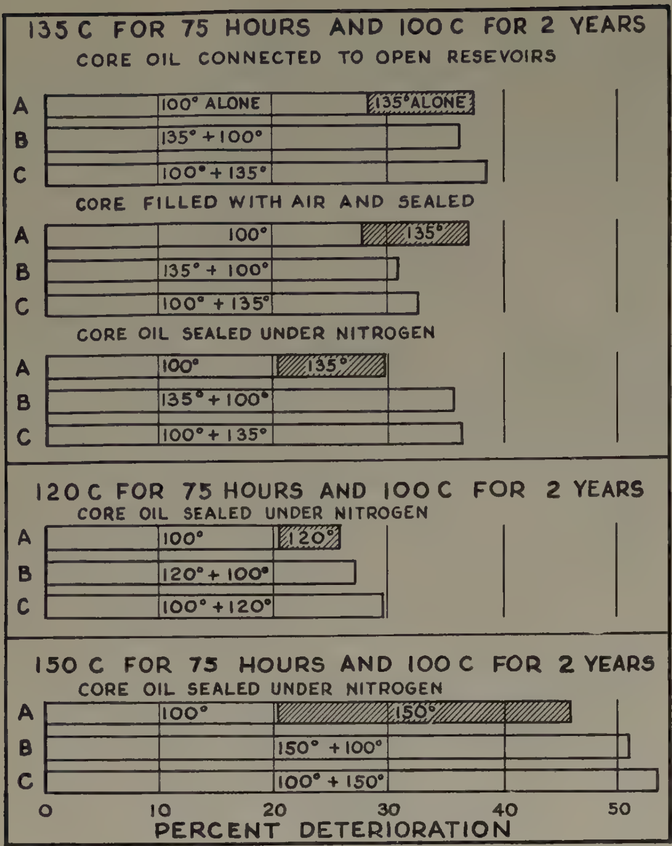


Figure 1. Deterioration of tearing strength of impregnated-paper insulation subjected to heat-aging tests

A—Independent effects of high temperatures for 75 hours and of 100 degrees centigrade for 2 years, determined independently on different samples
B—Combined effect of high temperature for 75 hours followed by 100 degrees centigrade for 2 years
C—Combined effect of 100 degrees centigrade for 2 years followed by high temperatures for 75 hours

and of repair time indicate that the lines and associated equipment should be capable of carrying an emergency load one-sixth greater than the normal load through one daily load cycle once a year.

2. For nine lines, supplying an a-c network, it might be necessary to plan for second contingency loading when two lines are out of service simultaneously, as occurring only twice during the entire life of the equipment.

3. For two overhead lines operated in parallel, lightning might cause outage of one line and impose extra-heavy loads on the other line once or twice a year for, generally, only a few cycles or a few minutes.

Incidentally, since increases in allowable load ratings sometimes create problems relating to setting relays, it is important to consider the need for changes in relay settings when establishing increased ratings.

BACKGROUND DATA ON TEMPERATURE EFFECTS

Considerable published data are available on the effects of a wide range of temperatures and temperature rises on the different types of electric equipment. Private information from other utilities and manufacturers has been used also. Over the years, the Commonwealth Edison Company has found it necessary also to make these long-time tests, which have ranged from a month to a decade in duration:

1. Accelerated-aging tests of a field installation of oil-filled cables and accessories at temperatures up to 140 degrees centigrade.
2. Accelerated-aging tests of experimental lengths of oil-filled cables in the laboratory.
3. Tests in ovens of sealed samples of solid-type paper-insulated cable and of varnished-cambric insulated cable at 100 and 125 degrees.
4. Accelerated-aging tests of 12-kv 3-conductor solid-type cable at temperatures up to 130 degrees and trial service operation of such cable with reduced conductor size and reduced insulation thickness.
5. Dummy-manhole tests to determine life of lead and lead-alloy cable sheaths until cracks develop under the effect of bending in the manholes incidental to daily load variations. (Research relating to this subject and to creep resistance of sheaths has been underway also at the University of Illinois.)
6. Aging tests of conventional and inhibited oils in distribution transformers at 90-degree top oil temperature. (A new extensive series of tests is now underway.)
7. Tests at various temperatures for weatherproof wire.
8. Laboratory tests of disconnects with copper-to-copper contacts and silver-to-silver contacts.
9. Oven-aging tests of impregnated-paper insulation.
10. Aging tests of contacts at high temperatures.

The results of these studies generally showed that it is feasible to load equipment to higher temperatures than were previously in use. (Partial exceptions to this statement apply to some of the results in items 5, 6, and 8.) Some of this information has been published previously.

The last two sets of studies were completed recently and the results have not been published previously. The data are given in some detail in the appendixes in the unabridged version of this article in the AIEE *Transactions*. Appendix I covers studies relating to heat aging of the insulation of transformers and cables, especially with reference to emergency loading. The results show that heavy emergency loading does not cause deterioration of a degree which is objectionable. The tests were made on samples of single-conductor oil-filled cable which were prepared in three different fashions before being placed in the ovens. A summary of the results is given in Figure 1.

Appendix II shows the results of studies of maximum safe temperatures for various types of contact surfaces for 95 copper members in the form of busses or terminal lugs. Figure 2 shows one of the test schedules. The data indicate that the temperatures used in Chicago for bolted contacts are conservative, even though those temperatures for normal operation are 15 degrees centigrade higher than in the national standards; and those temperatures for emergency operation are much higher still.

RELATION BETWEEN LOADING AND TEMPERATURES

The determination of the loading corresponding to the established permissible temperatures is based on a

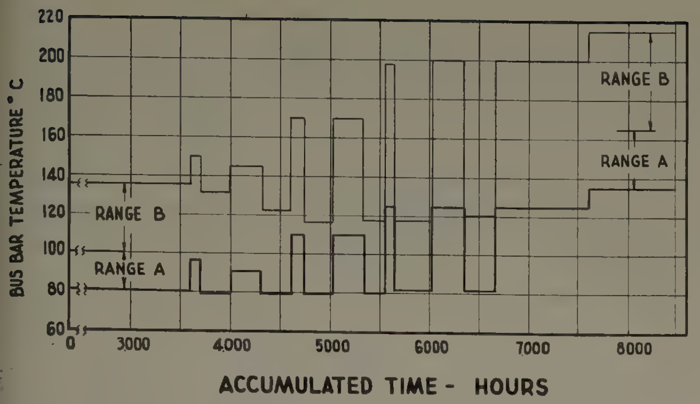


Figure 2. Schedule of heat-aging tests of bolted connections on bus bars

Temperatures for copper-to-copper connections were in range A. Temperatures for copper-to-silver and silver-to-silver connections were in range B. The intermediate lines at the start and the end of the tests show the maximum for the portion of the setup with copper-copper contacts and the minimum for the portion with copper-silver and silver-silver contacts

detailed study of the specific local conditions for the equipment including ambient temperature, ventilation, nature of installation, and nature of load cycle. The calculations are based on theoretical formulas. Constants and the resistances of complex thermal paths have been determined experimentally in the laboratory for use in connection with the general formulas. In addition, field check tests are made; these include tests on large transformers and associated apparatus, network protectors, and underground lines. Detailed data are obtained from the factory tests of transformers, especially of moderate and large size, as to the actual thermal characteristics. In connection with the lines, over 3,000 measurements of the temperature of the air in idle inner ducts of conduits throughout the city are obtained each summer.

ACTION BASED ON INVESTIGATIONS

Table I gives some idea of the maximum temperatures used, which are in most cases higher than those in industry standards. An outstanding example of the benefits of these studies is the increase in allowable temperature for low-pressure oil-filled 138-kv cable from 65 degrees as set by the manufacturer in 1927, to emergency operating limits as high as 110 degrees nowadays.

An example of the maximum ratios of the capabilities to name-plate rating is given in Table II. The figures given are for the half-hour peak load capabilities of distribution substation transformers in connection with their daily load cycles. These ratios are in contrast with the former limits of 125 and about 100 per cent of name-plate rating which had been used in Chicago during emergency and normal operation, respectively.

In the work on establishing load capabilities for a given associated group of elements, it is found very frequently that a few of the elements seriously limit the over-all load capability. For example, for a transformer connected to the two voltage busses, detailed studies on associated equipment revealed in some cases that the normal load capability for a lead or disconnect was even less than the name-plate rating of the transformer. It has been found that with the expenditure of a small percentage of the total cost of the installation, the load capabilities of the complete installation may be increased by 10 to 60 per cent. In one case, the emergency load capability of a long 69-kv underground line and associated equipment, including transformers, was increased 30 per cent by making temperature changes in associated equipment at a cost of only 2 per cent of the original total cost of the installation. No changes were made in the underground cable itself, but increased temperatures were used.

The policy of obtaining co-ordinated load capabilities for all types of operation is now being applied to considerable advantage for new installations on the electric system, and in connection with installations of steam-generating units associated with turbine-generators.

Table I. Examples of Maximum Temperature Limits Used in Chicago

Note: Due to the nature or condition of the particular equipment involved, or to the nature of external conditions affecting it, the temperatures used for a specific case might have been somewhat less than shown in the table.

Apparatus	Maximum Temperature Limits (1)—Degrees C: Normal Operation	Emergency Operation 1–5 Days (2)
(*a*). Insulated Cables		
Paper-insulated		
240-volt	95	125
4-kv	90	110
12-kv, shielded, 3/c	85	105
138-kv, oil-filled	80	110
Varnished-cambric, 1/c, 12-kv	77	93
(*b*). Overhead Cables		
Copper, bare (3)	85	100
ACSR, bare (3)	85	100
(*c*). Copper Bars and Rods		
Copper-copper contacts	85	120–125
Silver or silver-copper contacts	100	135–140
(*d*). Disconnects and Air-Circuit Breakers		
Copper-to-copper contacts	70	115
Silver-surfaced contacts	85	130
(*e*). Oil-Circuit Breakers		
Contacts, copper or silver surface	70	100
Contacts and all OCB connections silver surfaced	85	100
(*f*). Transformers' Hot Spot		
Large station-type transformers	100	130–135
Substation and network transformers	105	135–140
(*g*). Insulating Liquid		
Unprotected transformers—oil		90
Protected transformers—oil		100
Sealed a-c network transformers		110
(*h*). Temperature Rise of Air-Cooled Generators (4)		
Armatures by detector	60 and 65	
Special case	75 and 80	
Fields by resistance	85 and 90	
Special cases	90 and 100	

(1) The temperatures given are for the conductor itself, except for items *g* and *h*.

(2) a. The expected duration of the emergency loading varies with the system conditions involved and with the time required for repairs to failed equipment that necessitates emergency operation. Generally the duration is from 1 to 5 days. The appropriate time is used in the calculations of each emergency load capability. In a few cases, the duration is small, such as 1 hour.

b. Other temperatures, intermediate between those shown in the two columns, are established for special cases either where there is planned operation at high loads for several days each year or where there may be rare emergency operation for, say, 2 months.

(3) Higher temperatures are permissible for some special types of copper. For emergency operation lasting a few hours or less, temperatures higher than 100 degrees have been considered in Chicago satisfactory for ordinary copper and even more so for steel-reinforced aluminum cable (ACSR) with seven or more steel strands. When designing for use of higher temperatures than given in the table, special consideration is given to sag and to connectors.

(4) Five-degree-higher values for temperature rise are allowed for winter operation than for summer operation. For armatures of hydrogen-cooled generators, an attempt is made to use, for heavy loading, limits for hot-spot copper temperatures estimated to be about equal to the copper temperatures corresponding to the rises of 60 and 65 degrees given in item *h*.

PROCEDURES TO OBTAIN FULL UTILIZATION OF LOAD CAPABILITIES

THE FOLLOWING PROCEDURE has been developed in order to obtain the best utilization of equipment:

1. Study actual thermal conditions for specific installations. Separate and higher load ratings are usually established for winter operation.
2. Study load and service conditions, including load factors, to which equipment will be subjected.
3. Determine maximum temperatures and temperature rises permissible for normal and for emergency operation under these conditions. In establishing the temperatures, consideration should be given to the nature and condition of the equipment.
4. Determine load capabilities on the basis of these limits.
5. Study limitations in capabilities with relation to expected load requirements.
6. Determine most economical means of elimination of limitations or of bottlenecks imposed by specific portions of an installation.

The study of methods of increasing capabilities has developed a number of possible schemes including:

1. Use of fans may solve the problem for special conditions of associated equipment, such as where heat dissipation is poor due to enclosures, or where the required loading of the equipment is a little higher than the originally planned figures.
2. The emergency capability of a self-cooled transformer itself may be increased by the use of portable fans.
3. Placing transformers outdoors may increase the permissible temperature rise by 10 to 15 degrees.
4. Improvements in ventilation of enclosures of equipment such as drilling holes in or partial opening of enclosures.
5. Silverplating the contact surfaces of disconnects increases the normal load capability by 20 per cent or more.
6. Where underground conduit and cable systems are present: (*a*) Use of large-sized cable in the portions of a given line that are in heavily occupied conduits or in locations with soil of poor heat conductivity. (*b*) Replacement of thermally-poor soil around conduits with soil having good thermal conductivity.

RESULTANT CHANGES IN ACTUAL LOADING

THE FOLLOWING DISCUSSION of the effects of changes in allowable loading on the changes in actual loading shows the direct results of the establishment of new normal load capabilities and of emergency load capabilities. Table III was prepared to show how the average of maximum normal loadings has increased in several categories. The reference year for the former actual loadings was so selected that it was representative for the maximum loading under the former load ratings, that is, at a time, for example, when any extra plant capacity that existed incidental to the depression in the 1930's had been used up. Incidentally, the effect of the new capabilities on the average loading has not developed fully yet.

Table II. Limits of Load Capabilities Established for Large 12–/4-Kv Transformers

Season	Temperature-Rise Limit in Design for Name-Plate Rating	Maximum Value of Ratio of Load Capability to Name-Plate Rating: Normal Operation	Maximum Value of Ratio of Load Capability to Name-Plate Rating: Emergency Operation
Summer	40	1.65	1.90
Summer	55*	1.44	1.65
Winter	40	1.90	2.00
Winter	55*	1.70	1.85

* Limit for standard transformers furnished in past 3 decades.

Table III. Increases in Actual Loading of Equipment

Equipment	Reference Year to Represent Full Use of Previous Practices	Average Increase in Maximum Normal Loading Since the Reference Year—Per Cent
4-kv transformers	1937	38
12–/4-kv transformers	1944	22
4-kv cable feeders	1939	14
12-kv cable lines	1939	18
Generators	1946	Up to 10

For each category, the loadings of individual items or lines have been much above the averages given in the table. For instance, the maximum during normal operation for the 12–/4-kv substation transformers for the winter of 1951–52 was between 130 and 138 per cent of name-plate ratings for five transformers. Higher loads have been carried on a few transformers during emergencies.

On turbine-generators, some units have operated frequently with armature currents of 5 to 10 per cent over the name-plate ratings in the wintertime. Usually the operation at such loads has been for an hour or two at a time. The emergency load capabilities range up to about 15 per cent above name-plate ratings.

EFFECT ON OPERATION

THE EFFECT OF the increased loadings has been to increase maintenance or the rate of failures, or both, to a small extent for some equipment, and to no noticeable extent for other equipment. In no case has the increase, if any, had any particular effect on service reliability. For 4-kv distribution transformers, where the rate of failures due to all causes was 0.53 per cent per year in the period of 1935–37, it was 0.61 per cent in 1949–51. Examinations show that a large majority of the failures have been due to causes other than the effect of high loading, but it is difficult to get enough data in most cases to say exactly how many failures were due to high loading.

For the 12–/4-kv transformers, the average rate of failures in the period 1935–45 was 0.8 per cent per year, while in the period 1946–51, the average rate was only 0.65 per cent per year. In neither period was the cause of failure apparently associated with the size of the load. During normal operation in the first period, none of the transformers that failed had carried more than name-plate rating, while half of them had during the second period. Regarding the latter, none of the failures was ascribed to effects of heavy loading.

On cable feeders, the main effect of the increased loading

has been to increase the number of cracks in sheaths due to the daily small bending in manholes. Over 80 per cent of these sheath cracks are found by inspection before they cause service failure. The record of service failures due to these sheath cracks is given in the following:

	Total Number of Service Failures*		Failures Per 100 Miles of Cable Per Year	
	1939–41	1949–51	1939–41	1949–51
4-kv cable	1	26	0.03	0.64
500,000-cir-mil 3/c 12-kv cable	8	32	0.31	1.03

* All failures occurred in sheaths of ordinary lead. Only alloy lead used on such cable purchased in recent years.

It may be noted that even with the present increased rate of trouble due to sheath cracks, the present rate for the 4-kv feeders is now only one-tenth of the total rate of failures in cable and accessories due to all causes. For the 12-kv feeders, the ratio is one-fifth.

The increased loading of generators has had no deleterious effects, except in a very few cases where measurements after the establishment of the new load capabilities disclosed that severe local heating of the insulation of the armature coils near magnetic end fingers was much greater than previously estimated. On disconnects of the old type with copper-to-copper contacts with little pressure, it is frequently found in the course of routine periodic inspections that the temperature rises are high, although the loads have been slightly to substantially less than the name-plate ratings. Proper maintenance of such disconnects generally reduces the temperature rises to much less than 30 degrees.

For some types of equipment, the results of tests and operating experience to date indicate that still higher temperatures than are used should be feasible. Such increases will be dictated by needs and opportunities as they arise and by the results of further studies, further operating experience, and supplementary test data.

EFFECTS ON COSTS

Some examples are in order to show the effects of the increased loading in line with the newly established load capabilities to decrease the amount of additional equipment needed to take care of load growth. For the 4-kv overhead distribution transformers, the total of the name-plate ratings increased from 1,158,000 kva in 1937 to 1,634,000 kva in 1951. If the practice in 1951 had been to load such transformers as they had been loaded in 1937, then the required total in terms of name-plate ratings would have been 2,260,000 kva. The expense of installing 626,000 kva of transformers was saved.

For the 12-/4-kv substations, the corresponding saving, which has been achieved since 1944, has been about 240,000 kva in transformers and associated equipment and structures. For one type of 12-kv lines which serve groups of system substations, the number grew from 179 in 1939 to 210 in 1951. If the loading per line in 1951 had been the same as in 1939, then 249 lines would have been required.

Similar details could be given on other large savings realized, such as on transformers, underground transmission lines, and generators in the bulk-power system. In some cases, however, the best loading is below the load capabilities. For instance, on bare overhead lines where the cost of the conductors is a relatively small part of the total cost of the installation, the cost of losses, especially with a high load factor, may dictate the most economical conductor size. Also, voltage regulation requirements may dictate the size.

In order to carry on this load capability work, there are the costs for making laboratory and field tests and for engineering to handle all of the diverse problems relating to the establishment of the capabilities. These expenses are, however, very small as compared to the resulting savings in investment.

The increase in maintenance and repair costs due to increased loadings has been relatively insignificant. Also, generally the losses per kilovolt-ampere transmitted have been greater than they were before the increased load ratings were established. However, for the type of equipment being discussed, that is, cables, transformers, generators, and so forth, and associated equipment and structures, these increases in losses per kilovolt-ampere have been found to be small as compared to the savings in fixed charges.

CONCLUSIONS

In connection with this work on establishing and using increased load capabilities, a few general observations may be in order. First, the operating personnel should be given information which will show that the increased loadings resulting from higher ratings will be reasonable from the standpoint of service reliability and maintenance. The specific load ratings issued to operating people should be in a form that co-ordinates directly with standard load measurements without interpretation. Second, the system planning and designing of installations should be such as to take advantage of the increased capabilities, including the work on co-ordination to eliminate existing bottlenecks, and to avoid them in future installations. Third, the engineers directly associated with the work on increased load capabilities should maintain a lively curiosity and obtain information regarding all of the various problems relating to the establishment and the usage of such load capabilities.

When inherent thermal limitations that apply generally to a part of a given type of equipment or to part of a given type of installation are discovered, they should be brought to the attention of the manufacturers or of utility planning or design engineers, as circumstances warrant. This procedure has resulted, for example, in the following developments by manufacturers: silver-surfaced contacts; redesign of end structure of armature cores; lead-alloy sheaths instead of ordinary lead sheaths; inhibited oil for replacement of conventional oil in existing transformers; and insulations so made and applied as to withstand increased temperatures.

As a result of adopting the ideas and applying the data and techniques herein discussed, one utility has been able, in recent years, to effect a substantial saving in investment.

Summer Meeting in Atlantic City Offers Outstanding Program, Vacation Facilities

The AIEE Summer General Meeting for 1953 will be held in Atlantic City, N. J., June 15–19, with headquarters at the Chalfonte-Haddon Hall Hotels. An outstanding technical program plus the facilities that make this site one of the country's foremost vacation spots should ensure a highly successful meeting and members who expect to attend should make their plans now. Arrangements also have been made to have at least 40 students from various engineering schools present as guests of the AIEE Philadelphia Section, sponsor of this year's Summer Meeting.

TECHNICAL PROGRAM

The annual business meeting on Monday morning, June 15, will signal the beginning of 5 days of technical sessions and symposia as outlined in the following:

Monday, June 15

9:30 a.m. Annual Meeting
1:30 p.m. Protective Devices
Electronic Power Converters
Computing Devices
Substations
Instruments and Measurements
Facsimile

Tuesday, June 16

9:00 a.m. Section Delegates' Conference
Electrical Techniques in Medicine and Biology
Television
Relays
Computing Devices
Instruments and Measurements

1:30 p.m. Section Delegates' Conference
Nucleonics and Electrical Techniques in Medicine and Biology
Management
Aural Broadcasting
Electron Tubes
Basis for Utility Charges for Service to Resistance Welders
Instruments and Measurements

Wednesday, June 17

9:00 a.m. Land Transportation
Switchgear
Insulation
Magnetic Recording
Electronic Systems Reliability
Nucleonics and Power Generation
Instruments and Measurements

1:30 p.m. Transistor Standardization
Switchgear
Synchronous Machinery
Special Communication Applications
System Engineering

Thursday, June 18

9:00 a.m. Safety
Magnetic Amplifiers
Wire Communications
Power Generation
High-Dielectric-Constant Ceramics
Electronic Circuit Principles
Electronic Instruments

1:30 p.m. Magnetic Amplifiers
Wire Communications
Power Generation
Insulated Conductors
Basic Science
Transformers
Electronic Instruments

Friday, June 19

9:00 a.m. Communication Switching
Transformers
Transmission and Distribution
Basic Science
Power Generation

1:30 p.m. Radio Communications
Transformers
Transmission and Distribution

RECREATION

In addition to an unusually interesting technical program, Atlantic City and the Chalfonte-Haddon Hall Hotels will provide a restful, pleasant atmosphere in which to spend an enjoyable vacation. A special Hotel Accommodations Desk, manned by members of the Hotel Committee, will assure the best utilization of the hotels' facilities. Train, airplane, bus, taxicab, and limousine service will be available through the Transportation Committee, members of which will be on hand to provide information.

Those who wish to play golf will find an excellent course at the Atlantic City Country Club; prizes will be awarded for both women and men. Facilities for fishing will be available also, with prizes for both the largest and smallest fish caught. Men, women, and children are all eligible.

Under sponsorship of the Ladies' Com-

Members of the Atlantic City Division of the Philadelphia Section serving on the Summer General Meeting Committee meet to talk over final arrangements for the convention in June. Left to right: John Chew, Sports; J. B. Taylor, Hotel; L. C. Roe and Lea Schneider, Promotion; Waldo Caven, Sports; Charles Behler, Membership

Future AIEE Meetings

North Eastern District Meeting
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
including
Northern Textile Conference
Sheraton Plaza Hotel, Boston, Mass.
May 1, 1953

AIEE-IRE-RTMA-WCEMA West Coast Electronics Conference
Shakespear Club, Pasadena, Calif.
April 29–May 1, 1953

AIEE-IRE-ISA-IAS Telemetering Conference
Edgewater Beach Hotel, Chicago, Ill.
May 20–22, 1953

Conference on Electric Heating
Detroit-Leland Hotel, Detroit, Mich.
May 26–27, 1953

Summer General Meeting
Chalfonte-Haddon Hall Hotels,
Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—closed*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 3*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Aircraft Electric Equipment Conference
Benjamin Franklin Hotel, Seattle, Wash.
September 30–October 2, 1953

Conference on Fractional-Horsepower Motors
Fort Wayne, Ind.
October 6–8, 1953

Conference on Machine Tools
Cleveland Hotel,
Cleveland, Ohio
October 14–16, 1953

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

mittee, an informal family get-together tea has been arranged for Sunday, June 14, and a coffee hour is scheduled for each morning of the meeting. The ladies' program also will include sight-seeing trips, a millinery show, an afternoon cruise, and an inspection of the hotel kitchens.

A well-rounded program of family entertainment has been prepared, with a bingo party and card party scheduled for Monday night. The show and dinner on Tuesday evening promises to be a gala affair, with a selected dinner from the cuisine of the Haddon Hall kitchen accompanied by music and entertainment from radio, television, and the opera. On Wednesday evening a cabaret dance, including square dancing, will be held in the Chalfonte-Haddon Hall Hotels. A moonlight trip along the island off Atlantic City has been planned for Thursday evening.

Because this meeting is expected to attract a large attendance, early hotel reservations are advisable. A card for this purpose accompanies the mailed meeting announcement.

For Sections interested in showing a motion picture describing Atlantic City, a film which already has been exhibited at a number of Section meetings may be obtained through the Philadelphia Section.

COMMITTEE PERSONNEL

Members of the committee for the 1953 Summer General Meeting are: L. R. Gaty, General Chairman; B. L. England and W. F. Henn, Vice-Chairmen; R. W. Wilbraham, Treasurer; A. C. Muir, R. M. Pfalzgraff, D. B. Smith, and J. C. Strasbourger, Members at Large; A. D. Brown, Sports; W. R. Clark, Technical Program; H. F. Davis, Hotels; W. F. Denkhaus, Arrangements; J. B. Harris, Entertainment; W. G. Salmonson, Transportation; T. E. Stieber, Registration; M. L. Stoughton, Promotion; S. R. Warren, Students; R. W. Wilbraham, Finance; Mrs. H. R. Paxson, Ladies.

North Eastern District Meeting Opens in Boston on April 29

With historical Boston as its site and the golden anniversary of the Boston Section as its theme, the 1953 AIEE North Eastern District Meeting gets under way on April 29 at the Sheraton Plaza Hotel. The meeting, which will extend through May 1, features a comprehensive technical program including sessions on relaying, communication transistors, voltage regulation, power system communications, magnetic amplifiers, industrial power distribution, general equipment design, high-voltage transmission, power generation, productive maintenance, and industrial process control. Also, the Northern Textile Conference, annually sponsored by the AIEE Textile Industry Subcommittee, will be held in conjunction with this meeting.

Several interesting inspection trips have been arranged for those attending the North Eastern District Meeting. These will include, in addition to those trips previously announced, a visit to the General Radio Company, Cambridge, Mass., scheduled for Wednesday afternoon, April 29. This company, a small one by today's standards, is often considered the best-known manufacturer of electronic test equipment in the country. Visitors will see the engineering laboratories and Cambridge plant where more than 200 types of test instruments are produced annually.

The social aspects of the meeting have not been overlooked and an excellent program of entertainment has been planned, as well as a number of special activities for the ladies ranging from sight-seeing tours to a demonstration of oil painting and a talk on "The Secrets of the Powers' Girls." The city of Boston itself, of course, is rich in tradition and historical associations and has much to offer the visitor.

For the complete technical program and other details of the North Eastern District Meeting, see the April issue of *Electrical Engineering*, pages 358–61.

Program Announced for First Conference on Electric Heating

A special 2-day Conference on Electric Heating will be held at the Detroit-Leland Hotel in Detroit, Mich., May 26 and 27, 1953. It will be sponsored by the Committee on Electric Heating and the AIEE Michigan Section in co-operation with the Industrial Electrical Engineers Society of Detroit.

This will be the first conference of its kind devoted to the various aspects of electric heating, ranging from furnaces to induction heating equipment, and will feature some 20 papers on the subject by experts in the field.

In addition to the technical program, two luncheons and a banquet are being planned. The following are the papers scheduled for presentation during the 2 days of the conference.

Tuesday, May 26

9:30 a. m. Furnaces

Salt Bath Furnaces and Their Application. *L. B. Rosseau*, Ajax Electric Company

Electric Furnaces for Brazing, Sintering, Aging, and Annealing. *A. R. Ryan*, General Electric Company

Special Atmospheres for Electric Furnaces. *A. G. Hotchkiss*, General Electric Company

Recent European Developments on Arc-Melting Furnaces. *W. B. Wallis*, Pittsburgh Lectromelt Furnace Corporation

2:00 p. m. General

Fluid Analogues for Heat Conduction in Industrial Electric Heating. *A. D. Moore*, University of Michigan

Catalytic Energy Recuperation for Electric Process Heating. *P. H. Goodell*, Catalytic Combustion Corporation

Using Electric Heat to Increase Productivity. *G. S. Young*, Kansas City Power and Light Company

Controls Contribute Safety—Dependability and Quality to Electric Heating Processes. *R. E. Yates*, Protection Controls, Inc.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in Atlantic City, N. J., at 9:30 a.m., Monday, June 15, 1953, during the Summer General Meeting.

At this meeting the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to I. F. Kinnard (AM '21, M '28, F '43).

Such other business, if any, as may properly come before the annual meeting may be considered.

Signed H. H. HENLINE
Secretary

Visitors to the North Eastern District Meeting in Boston, Mass., may inspect the Massachusetts Institute of Technology at Cambridge. Left, a new electron tube is shown in the making at the MIT Research Laboratory of Electronics. The unique building shown at right houses MIT's 12,000,000-volt electrostatic generator, one of the largest of its kind

A Chemo-Electrical Method for Controlling Furnace Atmospheres. *W. L. Besselman*, Leeds and Northrup

3:30 p. m. Fluid Mapper Discussion Group

Professor A. D. Moore

6:30 p. m. Banquet

Induction Heating Provides New Economies in Automotive Production. *H. B. Osborne, Jr.*, The Ohio Crankshaft Company

The Expanding Contributions of Electric Heating. *G. E. Whitewell*, Philadelphia Electric Company

Wednesday, May 27

9:30 a. m. Resistance and Radiation Heating

Electric Heating of Fluids. *L. P. Hynes*, Haddonfield, N. J.

This Amazing Heat. *C. F. Kreiser*, Edwin L. Wiegand Company

Radiant Heating From Film Resistors Applied to Large Surface Areas. *R. E. Crump*, Electrofilm Corporation

Glass Panel Radiant Heating. *E. B. Shand*, Corning Glass Works

Infrared Heating for Low-Temperature Service. *I. J. Barber*, Fostoria Pressed Steel Corporation

2:00 p. m. Induction and Dielectric Heating

Transverse-Flux Induction Heating Used in Continuous Heat Treatment of Nonferrous Strip. *R. M. Baker*, Westinghouse Corporation

A Comparison of Economics and Methods for Heating Steel Strip. *C. E. Peck*, Westinghouse Corporation

High Temperature With Induction Heating. *T. E. Chesnut*, Ajax Electrothermic Corporation

High-Power Dielectric Heating for Industrial Use. *W. H. Hickok*, The Girdler Corporation, Thermex Division

Lehigh Valley Section Meeting

An outline of Great Britain's nationalized electric power industry was presented to members of the Allentown Division of the AIEE Lehigh Valley Section at their March 13 meeting by R. M. Pennypacker, Substation Superintendent of the Philadelphia Electric Company, who was among the engineers invited by the British Power Authority to study their system and make recommendations for increasing their productivity. D. A. Campbell, Jr. (left) Section Chairman, and John Hottenstein (center) program chairman substituting for S. C. Townsend, Allentown Division Manager, are shown in an after-dinner discussion with Mr. Pennypacker

Consultants Required for FCC Certification Service

Federal Communications Commission (FCC) certification of all industrial radio-frequency heating equipment (new or old) is required in accordance with the Commission's Rules and Regulations, Part 18, by June 30, 1953. Large numbers of installations are now causing serious interference to established communication and entertainment radio systems. In the interest of aiding all users of such equipment to comply with the FCC regulations, the AIEE Subcommittee on Induction and Dielectric Heating is desirous of compiling a list of all competent engineers or concerns capable of supplying technical assistance and FCC certification service to the user.

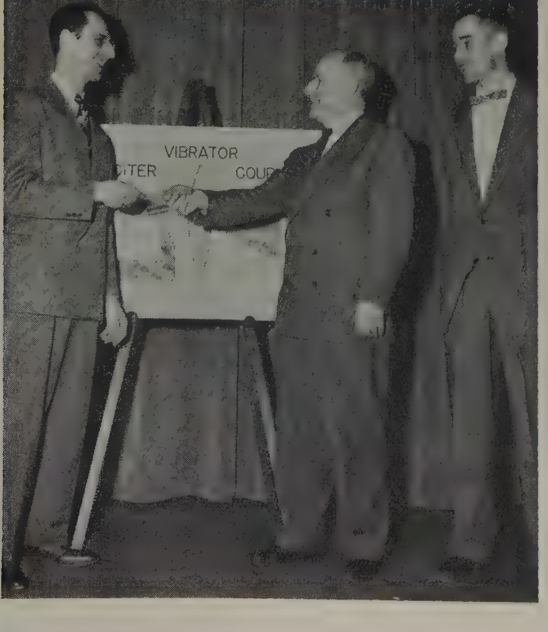
Persons or concerns in a position to supply this type of service may submit their names to C. A. Tudbury, Secretary, AIEE Subcommittee on Induction and Dielectric Heating; care of The Ohio Crankshaft Company, TOCCO Division, 3800 Harvard Avenue, Cleveland 1, Ohio.

General Committee Personnel Appointed for Fall Meeting

The following have been appointed to serve as members of the general committee which will make plans for the 1953 AIEE Fall General Meeting: C. G. Roush (*Chairman*), Riley Woodson (*Vice-Chairman*), S. H. Pollock (*Secretary-Treasurer*), J. E. Barfield, O. K. Johnson, C. M. Haynes, J. P. Kesler, William Carter, L. M. Schindel, R. L. Baldwin, A. C. Kirkwood, H. E. James, M. J. Horney, L. L. Davis, O. A. Starcke, D. G. Wilson, Mrs. S. H. Pollock.

This year's Fall Meeting will be held in Kansas City, Mo., November 2–6, with headquarters at the Muehlebach Hotel.

Lynn Section Holds Meeting



At a meeting on February 17, 1953, T. C. Sargent (center), Chairman of the AIEE Lynn (Mass.) Section, presents the first-prize award to G. P. Wozney (left) for his paper, "The Science of Musical Tones." At right is Chairman C. A. Woodman of the local convention committee. Second and third prizes went to L. E. Elvey and L. A. Lynch for their papers on "Pilot Ejection Systems" and "The Effects of Cloud Seeding." This local convention is an annual event to provide younger members with an opportunity to gain experience and win recognition in the writing and oral presentation of papers

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Communication Switching Systems (*John Meszar, Chairman; A. E. Frost, Vice-Chairman; William Keister, Secretary*). The Committee on Communication Switching Systems continued its effort to bring the interesting aspects of switching circuits and systems to the attention of a broader cross section of the engineering profession.

Several operating machines have been demonstrated. The general subject covers mechanized intelligence in switching circuits and systems. The subjects include discussion of telephone switching systems as examples of complex automata, a demonstration and explanation of the maze-solving mouse which is controlled by telephone-type relays, a discussion and demonstration of the principles of error-detecting and error-correcting codes, and a talk and demonstration of mechanized intelligence in nationwide dial telephone switching. Other discussions were directed toward specific telephone switching problems such as new developments in automatic recording and accounting for message billing purposes.

Continuing the program of covering material of broad interest, a session has been scheduled for the AIEE Summer General Meeting with the general theme of scientific methods employed in switching circuit design. This will include papers covering recent developments in the application of mathematical methods to the design of relay and electronic switching circuits and on the use of transistors in switching.

General Applications Division

Committee on Land Transportation (*L. W. Birch, Chairman; Jacob Stair, Jr., Vice-Chairman; G. M. Woods, Secretary*). The committee announced that the continued trend towards new rapid-transit lines and extensions of existing routes is encouraging to the transit industry. Plans involving surface rights-of-way are especially interesting because the investment required is much lower than for subways.

At the recent Winter General Meeting, problems were presented before the Land Transportation Committee covering rapid-transit developments in New York, N. Y., Chicago, Ill., and Boston, Mass. They included both subways and surface rapid transit, emphasizing the types of modern equipment developed for this service, also describing the latest designs of substations, overhead distribution, signaling, and interlocking.

An interesting session dealt with future trends in transit development of urban areas; electric trains operating in the center strips of freeways were offered as cheaper solution for the movement of large masses of passengers that cannot be handled conveniently and quickly with most surface vehicles.

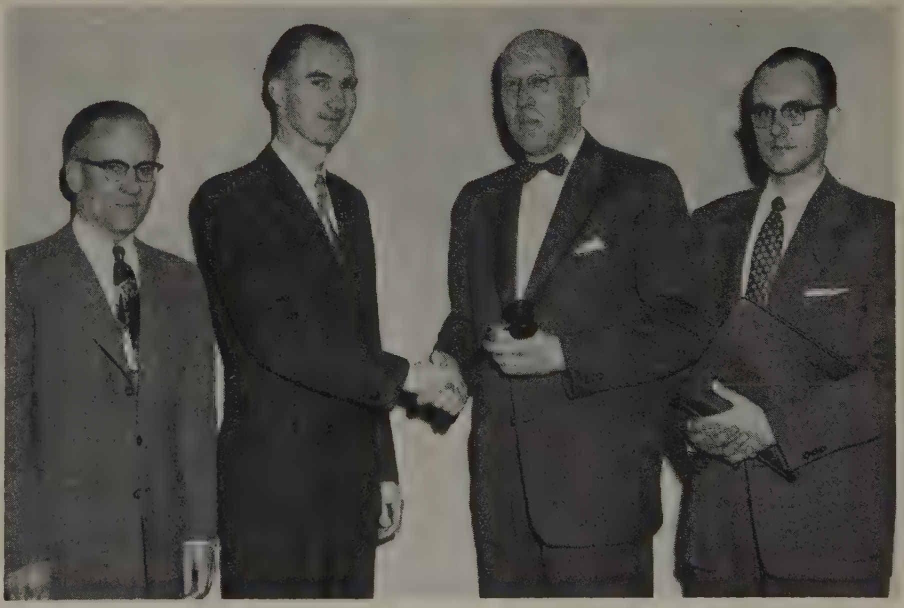
Industry Division

Committee on Feedback Control Systems (*F. E. Crever, Chairman; H. W. Cory, Vice-Chairman; L. C. Harriott, Secretary*). The Committee on Feedback Control Systems has two very active subcommittees. One is the Subcommittee on Terminology and Nomenclature which is working to submit a standard for approval to the AIEE Standards Committee. H. W. Cory is the chairman of this subcommittee. Much interest has been shown in this work both in the United States and abroad. Some of the work is controversial but every attempt is being made to obtain agreement through the American Standards Association with The American Society of Mechanical Engineers and the Institute of Radio

Philadelphia Section Broadcast

The Radio Program Committee of the AIEE Philadelphia Section witnesses the first broadcast of the program, "Meet the Engineer," being sponsored by the Section. Back row, left to right, are: Don Engles, Program Director, Station WFLN; M. L. Stoughton, Chairman, Radio Program Committee; K. H. Gordon, F. D. Brown, T. H. MacCauley, committee members. In the front row are R. D. Adams (left) and L. R. Gaty, who made the first program on the subject of "History of Engineering"

Seattle Section Elects Officers



Dr. L. J. Lewis (second from left) of the University of Washington, former chairman of the AIEE Seattle (Wash.) Section, here turns the gavel of his office over to his newly elected successor, J. M. Nelson, Assistant Superintendent, City of Seattle, Light Department. Other officers of the Section for the coming year are J. V. Lamson (left), Vice-Chairman, and W. J. Smith (far right), Secretary-Treasurer. Mr. Lamson is with the Bonneville Power Administration and Mr. Smith is associated with the Puget Sound Power and Light Company

Engineers who also have groups working on the subject.

It covers nomenclature and terminology based upon the comprehensive block diagram proposed in 1951. In addition, definitions descriptive of system performance have been prepared for submission as standard. This will be reviewed by the main committee at the AIEE Summer General Meeting after which it is planned to submit the material to the AIEE Standards Committee.

The Subcommittee on Bibliography has compiled and submitted the first two bibliography lists on the subject of feedback control systems. Part I covers general articles on feedback and its uses; Part II is devoted specifically to regulators; and Part III will cover other specific subjects in the field of feedback control systems.

Committee on Electric Welding (*C. N. Clark, Chairman; E. J. Limpel, Vice-Chairman; J. F. Deffenbaugh, Secretary*). A technical session on "Utility Charges for Service to Resistance Welders" is being arranged for the AIEE Summer General Meeting in Atlantic City, N. J. The organization work has been started for the Fourth Conference on Electric Welding to be held in Milwaukee, Wis., in May 1954. E. J. Limpel will be conference chairman.

The Subcommittee on Fundamental Electric Arc Research has completed a new "Bibliography on High-Pressure Electric Arcs," consisting of about 2,200 references. The present 200-page typed manuscript after reduction will be printed in a book of about 50 pages.

The Subcommittee on Instrumentation for Resistance Welding has held two meetings, in addition to its recent meeting in April. This subcommittee is working very closely with the AIEE Committee on Instruments and Measurements and the American Welding Society.

Power Division

Committee on System Engineering (*H. L. Harrington, Chairman; A. P. Hayward, Vice-Chairman; H. C. Otten, Secretary*). An all-day committee meeting attended by a majority of the committee membership was held in Chicago, Ill., in March to discuss subjects and projects to be undertaken in the future. This meeting at Chicago included a round-table discussion of service security of lines and systems.

Further study is being continued by the Subcommittee on System Controls on the general subject of load-frequency control.

Other subcommittees are studying subjects of particular interest arising from the adoption of higher transmission voltages for expanded system interconnections and the use of higher voltage outlet circuits for turbine-generator units of very large capacity.

Committee on Substations (*K. L. Wheeler, Chairman; I. S. Mendenhall, Vice-Chairman; R. F. Lawrence, Secretary*). The Committee on Substations has three active subcommittees on Transmission Substations, Distribution and Conversion Substations, and Automatic and Supervisory Control. These subcommittees are broken down into various working groups with such projects as Substation Grounding Practices, Utilization of Rectifier Switchgear, Safety Considerations in Substations, Circuit Breakers Versus Reclosing Fuses in Substations, Recommended Minimum Clearances, 1-Line Diagrams, and Location and Design of Distribution Substations in Residential Areas.

The Committee on Substations will sponsor a technical session at the Summer General Meeting which will cover grounding, circuit breakers versus fuses, minimum clearances, and 1-line diagrams.

Committee on Transmission and Distribution (*S. B. Crary, Chairman; F. V. Smith, Vice-Chairman; E. K. Huntington, Secretary*). The Tower, Poles, and Conductors Subcommittee of the Transmission and Distribution Committee sponsored a most interesting and valuable conference on wood and steel tower construction, including both electrical and mechanical characteristics. This committee is continuing its interest in the detailed design characteristics of towers, including design charts, sag-tension calculations, and characteristics of clamps. A working group has been organized to determine the basis of adequate clearances of high-voltage conductors so as to assist the AIEE member of American Standards Association Standard Committee *C2*, which committee is planning a revision of the National Electric Safety Code.

Science and Electronics Division

Committee on Basic Sciences (*R. M. Bozorth, Chairman; L. J. Berberich, Vice-Chairman; V. E. Legg, Secretary*). One of the main purposes of the Subcommittee on Magnetics of the Committee on Basic Sciences has been to hold periodic conferences on magnetic problems of current interest, at which a large group of magneticians gather to present papers and to discuss various topics informally. This year, at the AIEE Winter General Meeting there were about 400 in attendance. The papers included reviews of recent theoretical developments and summaries of applications of special interest, for example, ferrites for high-speed pulse circuits and for microwave frequencies, new alloys for power frequencies, and permanent magnets in which strategic materials, such as cobalt, are absent.

Subcommittee on Electron Tubes of the Committee on Electronics (*Scott Helt, Chairman; R. E. Higgs, Secretary*). The working group chairmen of the AIEE Electron Tube Subcommittee met with Professor C. H. Willis of the School of Electrical Engineering of Princeton University on March 18 to discuss electron tube standards.

The Electron Tube Subcommittee has originated a large group of tube definitions over the past few years, and Professor Willis told those present how these terms could be forwarded to American Standards Association for consideration and possible standardization. Professor Willis also instructed those present on how other standardization programs of the subcommittee might be conducted.

Present at the meeting were: H. C. Steiner, Chairman, Committee on Electronics; Scott Helt, Chairman, Electron Tube Subcommittee; E. I. Johnson, D. E. Marshall, and W. B. Whalley, chairmen of the various working groups.

This subcommittee has been very actively engaged in the promulgation of new tube definitions over the past several years.

AIEE PERSONALITIES.....

Stanley Stokes (AM '16, F '29, Member for Life), vice-president and chief engineer, Union Electric Company, St. Louis, Mo., has received one of the Missouri Honor Awards for Distinguished Service in Engineering, presented by the University of Missouri. Mr. Stokes was cited in recognition of "his brilliant career as an engineer in the field of electric power generation and distribution; for his many contributions to the design and construction of large electric power generating plants; for his successful guidance of a company that has solved the many problems of furnishing electric power to the metropolitan area of St. Louis; and for his professional leadership in pioneer enterprises concerned with the production of electric power by nuclear fission." Mr. Stokes graduated from the University of Missouri in 1912. He began his career with the Mississippi River Power Distributing Company assigned to construction on a Keokuk, Iowa, power receiving station. He was next employed by the Electric Company of Missouri and later became manager of the Outlying Plants Division of two small independent telephone companies for Union Electric. Rising to the position of chief engineer for Union Electric, Mr. Stokes had charge of the engineering and construction department. In 1950 Mr. Stokes was made vice-president and at present is representing Union Electric in the Monsanto Chemical–Union Electric joint atomic electric project. Mr. Stokes has served on the following AIEE committees: Membership (1933–34); Power Transmission and Distribution (1933–44); and Standards (1939–47).

W. H. Harrison (AM '20, F '31), president, International Telephone and Telegraph Corporation, New York, N. Y., has been elected a member of the Board of Trustees at Manhattan College, New York, N. Y. Mr. Harrison received an honorary degree of doctor of engineering from Manhattan in 1950. He has been president and director of International Telephone and Telegraph for 5 years. During World War II, Mr. Harrison was director, Production Division, War Production Board, and as a major general served as chief, Procurement and Distribution Service, Office of the Chief Signal Officer. In 1950–51 he was named administrator, National Production Authority. Mr. Harrison received the Hoover Medal in 1945. A former president of the AIEE

(1937–38) and vice-president, District 2 (1935–37), Mr. Harrison has been active on the following Institute committees: Technical Program (1929–36, Chairman 1931–33); Co-ordination of Institute Activities (1931–33); Publication (1931–33); Award of Institute Prizes (1931–34, Chairman 1931–33); Communication (1935–36); Edison Medal (1935–43); Lamme Medal (1935–38); Executive (1936–40, Chairman 1937–38); Institute Policy (1938–40); and others.

E. E. Kleinschmidt (M '22, Member for Life), president, Kleinschmidt Laboratories, Inc., Deerfield, Ill., was awarded a special citation by Chicago chapter, Armed Forces Communications Association, January 30, 1953, for "his distinguished contributions to the progress of civilian and military communications, particularly in the field of printed, electrically transmitted messages." The citation points out that "for 55 years Kleinschmidt has been tireless in his efforts to advance the art of civilian and military communications," and that "his own capacity for inventiveness and clear thinking has enabled him to develop the picture telegraph (1900); railway signalling devices (1910); the printing telegraph apparatus (1912) which later became known as Teletype; and the new lightweight high-speed Teletypewriter for the Armed Services of the United States (1945)." Mr. Kleinschmidt, who came to this country from Bremen, Germany, in 1898, soon afterwards opened his own electrical shop in New York, N. Y., and from 1913 to 1925 was president of Kleinschmidt Electric Company. He founded the Kleinschmidt Laboratories in 1931. In 1940 he received the John Price Weatherill medal from the Franklin Institute.

Waguar Ahmed (AM '49), Electrical Engineering Department, Engineering College, Dacca, East Pakistan, has been appointed professor and head of the Electrical Engineering Department. Dr. Ahmed was born in 1919 in Calcutta, India. He received his bachelors and masters degrees from the University of Calcutta and the electrical engineer and doctor of philosophy degrees from Stanford University. From 1943–45, Dr. Ahmed was with the All-India Radio, New Delhi. He carried out research at the Harris J. Ryan High-Voltage Laboratory, Stanford University, from 1946 to 1949, and was also a part-time instructor in the Electrical Machines Laboratory there. He was associated with the research group in the High-Voltage Engineering Laboratory of the General Electric Company, Pittsfield, Mass., during 1949–50. Since 1950 he has been with the Engineering College, Dacca. Dr. Ahmed is a member of the Institute of Radio Engineers, the American Association for the Advancement of Science, and Sigma Xi. He is also a member of the Council of the Institute of Engineers in Pakistan.

J. K. Nunan (AM '39, M '47), vice-president in charge of sales, Consolidated Engineering Corporation, Pasadena, Calif., has been elected executive vice-president and member of the Board of Directors of Consolidated Vacuum Corporation, Rochester N. Y., a subsidiary of Consolidated Engineering. For the 2 years prior to joining Consolidated Engineering, Mr. Nunan was employed by Howard Hughes in various administrative positions. Before that he served for 5 years as general manager of the Motion Picture Department of the Ansco Division of General Aniline and Film Corporation, Hollywood, Calif. Receiving his bachelor of science degree in electrical engineering from the University of Southern California and his master's degree from the California Institute of Technology, Mr. Nunan returned to the University of Southern California as instructor and head of the Electronics Division of the Electrical Engineering Department in 1938. He was subsequently appointed assistant dean of engineering and assistant professor of electrical engineering. During World War II, he was appointed to the staff of Columbia University's Division of War Research as Associate Director of the United States Navy Underwater Sound Laboratory, New London, Conn. In 1944 he was transferred to the staff of the Commander Submarine Force, Pacific Fleets, as director of the Pearl Harbor Laboratory. He received the Medal of Merit from the President of the United States in 1946 for the record achieved in these causes. Mr. Nunan is a member of Tau Beta Pi, Sigma Xi, and Eta Kappa Nu, and has served on the AIEE Committee on Electronics (1948–50).

R. F. Walz (M '50), sales engineer, Audio Products Corporation, Burbank, Calif., has joined the staff of the Bendix Computer Division, Bendix Aviation Corporation, Los Angeles, Calif., as a sales and engineering aid to the assistant general manager. Mr. Walz has been active in the communications and electronics fields for more than 25 years, joining Bell Telephone Laboratories in 1927 after his graduation from Northwestern University as an electrical engineer. He was later associated with Wired Radio, Inc., and International Business Machines Corporation. He directed the initial installation of instrument landing equipment at Los Angeles International Airport in 1942 as project engineer for International Telephone Development Corporation. In 1946 he was named chief radio engineer for Air Associates, Inc., and in 1948 established the Walkirt Company as co-owner. He sold his interest in the company in 1950 and joined the staff of Audio Products. Mr. Walz is a senior member of the Institute of Radio Engineers and a member of the Instrument Society of America.

V. A. Higgs (AM '43), assistant manager, Aero and Auto Equipment Sales Department, British Thomson-Houston Company, Ltd., Coventry, England, has been appointed manager of the department. Mr. Higgs, who was born in London, England, obtained his early practical engineering training as a British Thomson-Houston apprentice and his engineering education at the Northampton Engineering College, London University. After 6 years as a design engineer at Rugby, he was transferred to the Coventry works for work in connection with the windings of aircraft magneto, motor, and generator coils. In 1941 he was appointed senior technical officer at the Ministry of Aircraft Production in London and in 1946 returned to British Thomson-Houston. He became assistant manager of the Aero and Auto Equipment Sales Department in March 1951. Mr. Higgs is an associate member of the Institution of Electrical Engineers.

F. O. McMillan (AM '14, F '32, Member for Life), Head, Department of Electrical Engineering, Oregon State College, Corvallis, has been named Oregon's Engineer of the Year by the Professional Engineers of Oregon. The award in the form of a certificate of merit was presented to Professor McMillan "for his many contributions to the engineering profession, for his inspirational guidance and indoctrination of the youth of Oregon in sound engineering principles and high professional ethics, and for the recognition he has brought to this state as national president of a Founder society." Professor McMillan was president of the AIEE for 1951–52, and had previously served as vice-president (1934–36) and director (1948–52). He is also a member of the National Society of Professional Engineers, the Professional Engineers of Oregon, the American Association for the Advancement of Science, Society for the Promotion of Engineering Education, and the Institute of Radio Engineers.

D. L. Smith (M '27), general manager, Chicago, North Shore and Milwaukee Railway Company, Highwood, Ill., has been elected a vice-president of the company and will continue in charge of the operations of the railway with the title of Vice-President and General Manager. Colonel Smith is a graduate of the University of Illinois and has had wide experience in the transportation field starting work with the Chicago Rapid Transit Company in 1911, immediately after graduation. He was chief electrical engineer from 1926 to 1937 and was assistant to the executive officer when he entered active military service in World War II. Upon termination of his military service he was made assistant to the executive officer of the North Shore Line in 1945 and later assistant to the president. In 1947 he was made general manager. Colonel Smith is a member of the Western Society of Engineers and has served on the AIEE Land Transportation Committee (1937–43, 1946–53).

C. G. Veinott (AM '28, F '48), manager, Induction Section, Industrial Engineering Department, Westinghouse Electric Corporation, Lima, Ohio, has joined the Reliance Electric and Engineering Company, Cleveland, Ohio, as consulting engineer on a-c machinery. Born in Somerville, Mass., Dr. Veinott graduated from the University of Vermont in 1926 with a bachelor of science degree in electrical engineering. In 1938 he was awarded the professional degree of electrical engineer and in 1951 the University of Vermont conferred the honorary degree of doctor of engineering upon him. Dr. Veinott has been associated with the Westinghouse Electric Corporation for the past 25 years, being engaged chiefly in small motor engineering in plants in Springfield, Mass., and Lima. He is a member of the National

Society of Professional Engineers. A former vice-president of the AIEE, District 2 (1949–51), Dr. Veinott has served on the following Institute committees: Electric Machinery, Rotating Machinery (1934–38, 1942–53, Chairman 1951–53); Board of Directors (1949–51); Power Division (1951–53); and as Liaison Representative on Standards (1951–53).

H. E. Crampton, Jr. (AM '46), building and equipment engineer, Michigan Bell Telephone Company, Detroit, has been appointed assistant vice-president of the revenues department. Born in New York, N. Y., he was graduated from Columbia University in 1929 with a bachelor of science in engineering degree and received the degree of master of science in civil engineering there the following year. He joined the New York Telephone Company in 1930 as an engineering student and was given supervision of the depreciation and valuation work in 1936. In 1942 he was transferred to the American Telephone and Telegraph Company for engineering work along these lines and was appointed valuation and depreciation engineer of the Michigan Bell Telephone Company in 1946, holding that position until 1951 when he became building and equipment engineer. Mr. Crampton is the secretary-treasurer of the Michigan Section of the AIEE and served as vice-chairman (1951–52). He is a member of Tau Beta Pi, Sigma Xi, and the Engineering Society of Detroit.

E. C. White (AM '44), assistant to the sales manager of industrial and transmitting tubes, General Electric Company, Schenectady, N. Y., has been appointed to the newly created position of industrial specialist for the General Electric Tube Department. A native of Pittsburgh, Pa., Mr. White was graduated from the Carnegie Institute of Technology with a bachelor of science degree in electrical engineering in 1943. He joined General Electric on the company's test engineering program at Erie, Pa., in 1943 and in 1944 joined the Tube Department. He spent 2 years as the department's engineering representative to the Oak Ridge, Tenn., atomic energy plant, 3 years as district representative for industrial and transmitting tube sales in the Washington-Baltimore-Philadelphia area, and 2 years as supervisor for the sale of mercury switches. In 1951 he was named assistant to the industrial and transmitting tube sales manager. He is a member of Eta Kappa Nu.

H. S. Black (AM '23, F '41), transmission engineer, Bell Telephone Laboratories, Murray Hill, N. J., received the Research Corporation Annual Award for Contribution to Science in New York, N. Y., on January 23, 1953. Mr. Black, who joined the laboratories in 1921, was chosen the 1952 recipient of the award in recognition of his invention and development of the negative feedback principle and for his general record of contribution in the field of communications. A native of Leominster, Mass., Mr. Black received a bachelor of science degree in electrical engineering from Worcester Polytechnic Institute. In 1940 he was honored by the National Association of Manufacturers as a Modern Pioneer and holds the John Price Wetherill medal of the Franklin Institute. Mr. Black is a fellow of the Institute of Radio Engineers and a member of Tau Beta Pi, Sigma Xi, and the American Association for the Advancement of Science.

G. B. Ransom (AM '28, F '51), plant extension engineer, Long Lines Department, American Telephone and Telegraph Company, New York, N. Y., has been promoted to the post of assistant engineering staff manager. In addition to these duties, Mr. Ransom will be responsible for all general engineering planning. Mr. Ransom, a native of Marengo, Iowa, joined Long Lines as a technical employee in 1922 after graduating from the University of Minnesota with a bachelor of science degree in electrical engineering. He became district plant engineer in Indianapolis, Ind., in 1927 and division transmission engineer in Cleveland, Ohio, in 1928. In 1930, he was transferred to the engineering headquarters office at New York. He is a member of the Institute of Radio Engineers and Eta Kappa Nu. He has served on the AIEE Committees on Communication (1946–49) and Wire Communication Systems (1949–52).

H. D. Randall, Jr. (AM '33), acting executive director, Committee on Electronics, Research and Development Board, Department of Defense, Washington, D. C., has been appointed executive director of the committee. Mr. Randall has been associated with the Research and Development Board since March 1948, having served with the Planning Division, the Committee Co-ordination Division in the Office of the Vice-Chairman, and as acting executive director of the Committee on Electronics. From 1933 to 1948, he was associated with the Picker X-Ray Corporation in various offices. He served in the Aircraft Radio Division of the Navy's Bureau of Ships from 1943 to 1946. Mr. Randall is a graduate of Amherst College and Massachusetts Institute of Technology.

J. D. Ryder (AM '40, F '51), head of the electrical engineering department, University of Illinois, Urbana, has been named president of the 1953 National Electronics Conference. Other officers include **R. M. Soria** (AM '43, M '49), American Phenolic Corporation, Cicero, Ill., executive vice-president; **J. M. Cage** (M '44), Purdue University, Lafayette, Ind., secretary; **W. L. Emery** (AM '37, M '46), University of Illinois, Urbana, program committee chairman; **S. R. Collis** (AM '48), Illinois Bell Telephone Company, Chicago, publicity committee chairman; and **E. H. Finch** (M '50), Sargent and Lundy, Chicago, Ill., housing committee chairman. The conference is sponsored by the AIEE, Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and the University of Illinois, with participation by Purdue University and the University of Wisconsin. It will be held in Chicago, Ill., in September 1953.

F. E. Satterthwaite (AM '47), quality control engineer, General Electric Company, Pittsfield, Mass., has joined Rath and Strong, Inc., Boston, Mass. Dr. Satterthwaite, a 1936 honor graduate in engineering from Swarthmore College, won his doctorate in mathematics and statistics at the University of Iowa in 1941. For the last 6 years he has been quality control engineer and statistical consultant with General Electric. He has been a lecturer in quality control courses given at the University of Bridgeport, Rensselaer Polytechnic Institute, several sections of the American Society for Quality Control, and within the General Electric Company. He is a director and fellow of the American Society for Quality Control and a member of the American Chemical Society, Society for Advancement of Management, Society for Engineering Education, Institute of Mathematical Statistics, American Mathematical Society, and Sigma Xi.

Samuel Horelick (AM '17, F '40, Member for Life), Chairman of the Board, Pennsylvania Transformer Company, Pittsburgh, retired November 19, 1952. Mr. Horelick came to the United States in 1904 from eastern Europe and in 1912 received a degree in electrical engineering from Carnegie Institute of Technology. Upon graduation he was employed by Pittsburgh Transformer Company and in 1919 was appointed chief engineer. In 1928 the Pittsburgh Transformer Company became a division of Allis-Chalmers Manufacturing Company and the next year, 1929, Mr. Horelick organized the Pennsylvania Transformer Company. He served as president of the company from 1929 until 1949, at which time he became chairman of the board. Early in 1952 the company merged with the McGraw Electric Company. Mr. Horelick is a member of the Association of Iron and Steel Engineers and the Engineers Society of Western Pennsylvania.

R. M. Eaton (AM '17), superintendent and resident manager, Hazard Insulated Wire Works Division, The Okonite Company, Wilkes-Barre, Pa., retired December 31, 1952. Mr. Eaton had been employed by Okonite for nearly 45 years, joining the company at Passaic, N. J., in 1909 as an assistant in the electrical testing laboratory, of which he became the head 5 years later. He served as resident Navy inspector of war material during World War I. In 1925, when the Okonite-Callender high-tension cable division was started in Paterson, N. J., Mr. Eaton was transferred to this plant as its first superintendent. Three years later, he went to Wilkes-Barre as superintendent and resident manager of the Hazard Insulated Wire Works Division which was purchased by Okonite late in 1927. He served in this capacity for 25 years.

H. R. Hunkins (M '50), sales manager, Wire and Radio Transmission Systems, Federal Telephone and Radio Corporation, Clifton, N. J., has been appointed chief engineer in the Selenium-Intelin Division of the company. A native of Austin, Minn., Mr. Hunkins was educated at Columbia and Harvard Universities, re-

ceiving a bachleor of science degree in electrical communications from the latter institution. He joined International Telephone and Telegraph Corporation in 1929 and served for several years in the International Telecommunication Laboratories and the old Postal Telegraph Company. He was assigned to Federal Telephone and Radio in 1944 as product line manager in the Wire Transmission Division. He has also served as project manager for three of the company's Government contracts. He is serving on the AIEE Committee on Wire Communication Systems (1949–53).

W. H. Haines (AM '17, M '25, Member for Life), vice-president and general manager, Electric Specialty Company, Stamford, Conn., has been named president of the company. Mr. Haines was graduated from Columbia University with a degree of electrical engineer in 1912. Before joining Electric Specialty Company, he served in the engineering department of the Crocker-Wheeler Company, Ampere, N. J.; as assistant electrical engineer with Westinghouse, Church, Kerr and Company, New York, N. Y.; as a lieutenant in the United States Navy in World War I; and as assistant to electrical engineer of Bethlehem (Pa.) Shipbuilding Company. Mr. Haines started with Electric Specialty in 1921 and has served as sales engineer, sales manager, and vice-president and general manager.

H. A. Wright (M '48), engineer-in-charge, Control Sales Electric Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed assistant manager of sales of the company's control operation, Hawley Works. **T. B. Montgomery** (AM '36, F '49), engineer-in-charge, Control Section, Electrical Department, Allis-Chalmers, has been named chief engineer for the Hawley Works. **H. W. Cory** (AM '45), assistant engineer-in-charge, Control Section, has been appointed assistant chief engineer for the works. **T. H. Bloodworth** (AM '41, M '48), control section engineer, has been appointed engineer-in-charge, industrial control design.

J. E. House, Jr. (AM '49), Reliance Electric and Engineering Company, Cleveland, Ohio, has been appointed to the Pittsburgh, Pa., sales staff of the company. A native of Birmingham, Ala., and a graduate of Georgia Institute of Technology with a bachelor of science degree in electrical engineering, Mr. House joined Reliance in 1950 as a member of the engineering and industry sales staff in Cleveland. Previously he had been associated in various engineering capacities with the Tennessee Coal, Iron and Railroad Company, Birmingham, and the Humble Oil and Refining Company, New Orleans, La. Mr. House is a registered professional engineer in Ohio and a member of the Association of Iron and Steel Engineers.

C. H. Weiser (AM '43, M '47), plant personnel supervisor, Southwestern Bell Telephone Company, Topeka, Kans., has been elected president of the American Society of Safety Engineers for the year 1952–53. Mr. Weiser was born at Schell City, Mo., in 1889, and attended La Salle University and Washington University. In 1906 he went to work for a predecessor company of the present Bell System and has been employed by Southwestern Bell since its organization. He has been in virtually every phase of telephone company operations. Mr. Weiser is a registered professional engineer in both Kansas and Missouri and is a member of the National Society of Professional Engineers.

P. C. Smith (AM '26, M '48), assistant to division manager, Transportation and Generator Division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed manager of the division. Mr. Smith was graduated from the University of North Carolina with the degree of bachelor of science in electrical engineering. He then joined the Westinghouse graduate student training course at East Pittsburgh. In 1929, he was appointed design engineer of induction motors for the Transportation and Generator Division, and was named assistant to the manager of the division in 1944. In June 1952, Mr. Smith received the Westinghouse Order of Merit.

H. B. Wood (AM '19, F '38, Member for Life), chief electrical engineer, Stone and Webster Engineering Corporation, Boston, Mass., has been appointed construction engineer of the company. **R. R. Wisner** (AM '23, M '46), assistant chief electrical engineer, has been made chief electrical engineer; and **L. O. Waite** (AM '16, F '50), electrical engineer, has become assistant chief electrical engineer. Mr. Wood has served on the AIEE Committees on Protective Devices (1930–34) and Transfers (1948–53). Mr. Wisner is a member of the Committee on Power Generation (1949–53).

W. R. G. Baker (AM '19, F '47), vice-president, Electronics Division, General Electric Company, Syracuse, N. Y., has been elected a director of the American Standards Association, representing the Radio-Television Manufacturers Association. Mr. Baker has also been appointed treasurer of the Institute of Radio Engineers for the third successive year. A very active member of the AIEE, he has served on the following Institute committees: Award of Institute Prizes (1947–48, 1949–52); Electronics (1945–53, Chairman 1945–47); Standards (1945–47); Technical Program (1945–48); and Planning and Co-ordination (1947–50).

H. K. Wilcox, Jr. (AM '48), assistant sales manager, Switchgear Division, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been appointed sales manager of the R&IE Equipment Division, Greensburg, Pa. Mr. Wilcox joined I-T-E in 1936. With the exception of 4 years' service in the United States Army in World War II, he has been in sales work, chiefly in the Switchgear Division. On his return from the service in January 1946, he started as an application engineer until his appointment in 1948 to manager of equipment sales. Since 1949, Mr. Wilcox has been the assistant sales manager of the Switchgear Division.

Cledo Brunetti (F '48), associate director, Stanford (Calif.) Research Institute, will join the Mechanical Division of General Mills, Inc., Minneapolis, Minn., on March 1, 1953, as a research executive. Dr. Brunetti is a native of Minnesota and was graduated from the University of Minnesota, receiving the first doctor of philosophy degree in electrical engineering granted there in 1937. For 8 years before joining Stanford Research Institute in January 1949, he was with the National Bureau of Standards in Washington, D. C., lastly as chief of the Engineering Electronics Section. Dr. Brunetti has served on the AIEE Committees on Research (1949–53) and Electronics (1951–53).

W. H. Saalberg (AM '17, M '27), division underground engineer, Ohio Power Company, Canton, retired January 1, 1953. Mr. Saalberg was first employed by the Brown Hoist Company and the Cleveland Crane Engineering Company. Prior to joining Ohio Power, he worked in the West Indies installing heavy excavation machinery. He joined Ohio Power in 1921 when he started with the Distribution Department as a draftsman. Five years later he was named an engineer, and in 1946 he became division distribution engineer. He was named to his present job in October of the following year. He is a member of the Ohio Society of Professional Engineers.

S. D. Day (AM '48), plant records engineer, Ohio Power Company, Canton, has been named division superintendent of the company's Eastern Division. Mr. Day joined Ohio Power in 1922, when he started as a meter tester at the Canton General Office. Later that year and for the following 10 years, Mr. Day was a member of the American Gas and Electric Service Corporation's engineering department. He returned to Ohio Power in 1932 in the General Office Meter Department. He was transferred to Steubenville, Ohio, in 1934 where he later was named meter superintendent of the former Steubenville–East Liverpool Divisions. He returned to Canton in 1938 as an engineer.

J. H. Goss (AM '35, M '43), division manager of manufacturing, General Electric Company, Louisville, Ky., has been named general manager of the home laundry equipment department. Mr. Goss joined the company in 1931 as a test engineer at Schenectady, N. Y., a year after graduation from the University of Arkansas. In 1936 he was named engineer in charge of the works laboratory at West Lynn, Mass., and 10 years later he became assistant to the works engineer. He returned to Schenectady in 1947 as assistant division engineer of the control engineering divisions and later became assistant manager of engineering of the control divisions.

C. S. Beattie (M '40) and **R. E. Anderson** (M '41), vice-presidents, Delta-Star Electric Division, H. K. Porter Company, Inc., Chicago, Ill., have been elected vice-presidents of the H. K. Porter Company. Mr. Beattie will continue as general manager

in charge of all activities of Delta-Star Electric Division of the Porter Company. He joined Delta-Star in 1930 and had been executive vice-president of the division. Mr. Anderson will continue to direct the division's sales activities and commercial relations. He had been senior vice-president of the division.

P. L. Morton (AM '33, M '43), professor of electrical engineering, University of California, Berkeley, will become Chairman of the Division of Electrical Engineering on April 1, 1953. Dr. Morton received his bachelor of science degree from the University of Washington, his master of science degree from Massachusetts Institute of Technology, and his doctor of philosophy degree from the University of California. He was appointed instructor at the University of California in 1939, assistant professor in 1942, associate professor in 1947, and professor in 1952. He organized and developed the University Computing Center on the Berkeley campus. Dr. Morton is a member of the Committee on Computing Devices of the AIEE and has served on several committees of the San Francisco Section. He is a registered professional electrical engineer in the State of California.

David Sarnoff (M '23, F '51), chairman of the board, Radio Corporation of America, New York, N. Y., has been awarded the Annual Engineering and Science Award of the Federation of Engineering Societies of the Drexel Institute of Technology, Philadelphia, Pa. Mr. Sarnoff was cited in "recognition of his epochal contributions to the development of the science and art of radio communication in all its phases, from its crude beginnings in the days of damped wave telegraphy to its culmination in the highly refined instruments of modern television; and in appreciation of his notable achievements in promoting the manufacture and distribution of the implements of the radio art through which our civilization has been immeasurably enriched."

Yu-Hsiu Ku (F '45), visiting professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, has assumed duties as visiting professor of electrical engineering, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia. After earning a degree of doctor of science in 1928 at the Massachusetts Institute of Technology, Dr. Ku became dean of engineering at Central University, Nanking, China, and then dean of engineering and director of aeronautical and radio research at Tsing Hua University, Peiping, China. He was China's vice-minister of education from 1938 to 1944 and president of Central University in 1944–45.

H. E. Gumbart (AM '25), senior sales engineer, New Products Division, Corning (N. Y.) Glass Works, has been named western district sales representative of the company with headquarters in Los Angeles, Calif. Mr. Gumbart joined Corning in 1941 as a sales engineer in the Insulation Division. Later he was a sales engineer in the Electronics Sales Department of the Electrical Products Division. Prior to joining Corning, he worked in a sales capacity with Kennecott Wire and Cable Company. He holds an electrical engineering degree from Carnegie Institute of Technology.

F. A. Maxfield (AM '31, M '39), technical assistant to the officer in charge and principal civilian in the Torpedo Research and Development Branch, Navy Bureau of Ordnance, Washington, D. C., has been appointed manager of the Given Manufacturing Company's Research Laboratory in Washington, D. C. Dr. Maxfield was graduated from the University of Wisconsin in 1929 with the degree of bachelor of science in electrical engineering and received his doctor of philosophy degree there in 1938. He received his master of science degree in physics from the University of Pittsburgh in 1934. Dr. Maxfield went to work with the Navy early in 1941 from the faculty of the University of Wisconsin. He is a registered professional engineer in the District of Columbia, and a member of the American Physical Society, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

G. A. Porter (M '49), manager of construction, The Detroit (Mich.) Edison Company, has been made vice-president in charge of engineering, construction, and operations. Mr. Porter started with the company in 1925 in its Research Department. He was transferred to the Construction Department and later became assistant superintendent at the Delray Power Plant. In 1947 he was made assistant chief engineer of power plants and in 1949 became chief engineer of power plants. He was made manager of construction on January 1, 1952.

J. T. Kemper (AM '41), field engineer, Wagner Electric Corporation, Boston, Mass., has been appointed manager of the Boston Electrical Division Office. Following his graduation from the University of Missouri in 1940 with a bachelor of science degree in electrical engineering, Mr. Kemper joined Wagner as a student engineer. From 1941 he served as a field engineer in the Pittsburgh, Pa., office until 1946 when he was transferred to Boston.

P. W. Thompson (M '44), executive vice-president, The Detroit (Mich.) Edison Company, retired January 1, 1953. Mr. Thompson is a graduate of Cornell University, Ithaca, N. Y., where he taught in the engineering college for 3 years before joining The Detroit Edison Company in 1913. In 1931 he was made chief engineer of power plants and in 1943 he was elected vice-president in charge of engineering, construction, and operations. He was elected executive vice-president in December 1952.

M. G. Williamson (AM '51) and **C. J. Thiesen** (AM '50), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., have been assigned as sales representatives to offices in the Southwest region of the general machinery division. Mr. Williamson, an electrical engineering graduate of New Mexico College of Agriculture and Mechanical Arts, has been named to the Fort Worth, Tex., branch office. Mr. Thiesen, a graduate electrical engineer of Oklahoma Agricultural and Mechanical College, has been assigned to the Tulsa, Okla., district office.

R. D. Call (AM '43, M '49), industrial engineer, Engineering and Service Department, and **V. B. Wilfley** (AM '26, M '37), engineering supervisor, Engineering and Service Department, Westinghouse Electric Corporation, St. Louis, Mo., have been appointed St. Louis branch service manager and engineering manager, respectively. Mr. Wilfley was also appointed district engineering manager. Mr. Call has served on the AIEE Committee on Mining and Metal Industry (1951) and Mr. Wilfley on the AIEE Committees on Power Generation (1952–53) and Membership (1952–53).

A. S. Albright (M '37, F '43, Member for Life), treasurer, The Detroit (Mich.) Edison Company, has been elected executive vice-president. Mr. Albright, a native of Columbus, Ohio, was graduated from Ohio State University in 1912, and joined the Detroit Edison Company that same year. He served as superintendent of the Meter Department, head of the Research Department, and from 1943 to 1949 as Controller. In 1949 he was made treasurer and in 1952 a vice-president. He has served on the AIEE committees on Instruments and Measurements (1939–43) and Basic Sciences (1942–43).

I. H. Sublette (AM '50), electrical engineer, RCA Victor Division, Radio Corporation of America, Camden, N. J., has received an RCA Fellowship Award for graduate study toward a doctor's degree. Mr. Sublette will do graduate work in the Electrical Engineering Department of the University of Pennsylvania.

C. F. Herbold (AM '33, M '41), director, Manufacturing Planning, Westinghouse Electric Corporation, Lima, Ohio, has joined Jack and Heintz, Inc., Cleveland, Ohio, as director of Industrial Relations. Mr. Herbold, a graduate of Case Institute of Technology, joined the Cleveland division of Westinghouse in 1933. He was appointed manager of Industrial Relations at the Westinghouse Lima division in 1941. He is a member of Eta Kappa Nu.

C. B. Brown, Jr. (AM '50), field engineer, BullDog Electric Products Company, North Augusta, S. C., has been appointed to the Y-12 Plant, Oak Ridge, Tenn., of the Atomic Energy installations operated by Carbide and Carbon Chemicals Company.

R. C. Sprague (M '40, F '49), president, Sprague Electric Company, North Adams, Mass., has resigned. Born August 3, 1900, in New York, N. Y., Mr. Sprague was educated at the United States Naval Academy, the United States Naval Post-Graduate

School, and the Massachusetts Institute of Technology. He founded the Sprague Electric Company (originally the Sprague Specialties Company) in 1926.

A. Y. Bentley (AM '43), chief engineer, cathode-ray tube division, Allen B. Du Mont Laboratories, Inc., Clifton, N. J., has been named chief engineer of the receiver division. Mr. Bentley had been chief engineer of the Du Mont cathode-ray tube division since 1947. Prior to that time, he was assistant head of the cathode-ray tube engineering department, the position to which he was assigned when he joined the Du Mont organization in December 1945.

M. T. Smith (AM '32, '38), manager, Sales Engineering, General Radio Company, Cambridge, Mass., has been named sales manager. After his graduation from Massachusetts Institute of Technology, Mr. Smith joined General Radio Company as a development engineer. He served in this capacity until he was appointed manager of the New York district office. He subsequently managed the Los Angeles and Chicago districts, becoming sales engineering manager in 1944.

G. F. Schroeder (AM '49), senior design engineer, Electrical Development Laboratory, Ford Instrument Company, Long Island City, N. Y., has been appointed acting assistant chief engineer for air-borne equipment. A graduate of Columbia University in 1945, Mr. Schroeder worked as a design engineer at the Fairchild Pilotless Plane Division and at Boeing Aircraft before coming to Ford. He is a member of the Institute of Radio Engineers.

Max Skobel (AM '43), chief engineer, Aircraft Transformer Corporation, Long Branch N. J., has been appointed director of engineering and research. **D. E. Cavenaugh** (AM '45), assistant engineer, Aircraft Transformer Company, has been promoted to chief engineer. Mr. Skobel is a graduate of the College of the City of New York and Rutgers University. Formerly chief, transformer group, Signal Corps Engineering Laboratories, he was also head of the inductive components section, Armed Services Electro Standards Agency. Mr. Cavenaugh was formerly with Bell Telephone Laboratories. Both Mr. Skobel and Mr. Cavenaugh are members of the Institute of Radio Engineers.

V. M. Graham (M '47), director of technical relations, Sylvania Electric Products, Inc., Bayside, N. Y., has been appointed chairman of the Communications and Electronic Division of the Electrical Standards Board of the American Standards Association. Because of this position, Mr. Graham becomes also vice-chairman of the Electrical Standards Board. He also serves as technical advisor on electron tubes to the United States National Committee of the International Electrotechnical Commission. Mr. Graham is associate director of the Engineering Department of the Radio-Television Manufacturers Association and chairman of the Joint Electron Tube Engineering Council.

C. M. Slack (M '43), assistant manager, Atomic Power Division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named director of research and engineering, Westinghouse Lamp Division, Bloomfield, N. J. Dr. Slack came to Westinghouse in 1927 from a teaching position at Columbia University, from which he holds his masters and doctors degrees. He obtained his bachelor of science degree from the University of Georgia. He is a member of the American Association for the Advancement of Science and the American Physical Society. Dr. Slack has served on the AIEE Committee on Therapeutics (1947–50).

J. J. Brophy (AM '15, M '22, Member for Life), director of research, Physics and Chemical-Plastic Division, United Shoe Machinery Corporation, Beverly, Mass., was honored at a testimonial dinner, January 28, 1953, by his associates. Mr. Brophy has been with United Shoe for many years and expects to retire soon. His associates presented him with a scroll and a set of books. Mr. Brophy is a member of the American Chemical Society and the Society of American Military Engineers.

E. J. Szabo (AM '47), development engineer, Leece-Neville Company, Cleveland, Ohio, has been named chief engineer. Mr. Szabo, a graduate of Fenn College, joined Leece-Neville in 1942 as a design engineer and was appointed development engineer in 1949. Mr. Szabo is a member of the Society of Automotive Engineers.

Leo Botwin (AM '47), senior project engineer, Sperry Gyroscope Corporation, Great Neck, N. Y., has joined the Ketay Manufacturing Company, New York, N. Y., as director of systems engineering. He joined Sperry in 1947 as project engineer and became a senior project engineer in 1951. Mr. Botwin is a member of Tan Beta Pi and Eta Kappa Nu.

H. E. Kranz (AM '17, M '23), director, technical institute division, Lawrence Institute of Technology, Detroit, Mich, has been appointed head of the electrical engineering department. Dr. Kranz is a member of the Institute of Radio Engineers and the Engineering Society of Detroit.

H. C. Guterman (M '50), director, Freed Electronics and Controls Corporation, New York, N. Y., has become chairman of the executive committee of the board of directors. Mr. Guterman was formerly a director and president of Arma Corporation and a director of American Bosch Corporation.

J. G. Thomas (AM '50), transmission sales engineer and testing engineer, American Steel and Wire Company, Cleveland, Ohio, has joined The Electrical Distributors Company, Philadelphia, Pa., as sales engineer.

E. H. Schulz (AM '37, F '50), manager, Physics and Electrical Engineering Division, Armour Research Foundation, Chicago, Ill., has been promoted to director of research. While completing work on his doctorate at Illinois Institute of Technology in 1946, Dr. Schulz was appointed assistant chairman of the Foundation's Electrical Engineering Department. The following year he was named department chairman. He is a member of the Institute of Radio Engineers.

J. C. Sonntag (AM '46), assistant to superintendent, Power Manufacturing Department, Hartford (Conn.) Electric Light Company, has been appointed assistant superintendent of power. He has been associated with the company since 1936. He is a native of Brooklyn, N. Y., and was graduated from Rensselaer Polytechnic Institute as an electrical engineer in 1931.

J. M. Duff (AM '47, M '51), electrical design engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been assigned to the company's sales application engineering staff, Boston, Mass.

F. B. Gregersen (AM '52), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed an installation superintendent for the southeast region with headquarters in Atlanta, Ga.

J. H. Frankel (AM '52), engineer, New England Telephone and Telegraph Company, Boston, Mass., and **G. W. Lutka** (AM '50), technical assistant, Worcester (Mass.) County Electric Company, were initiated into Sigma Epsilon Rho, a Northeastern University School of Business honor fraternity, March 14, 1953.

Leon Podolsky (M '45), manager, Field Engineering Department, Sprague Electric Company, North Adams, Mass., has been appointed to the newly created post of technical assistant to the president. **C. G. Killen** (AM '42), chief application engineer, succeeds Mr. Podolsky as manager of field engineering.

R. P. Pfeiffer (AM '45), assistant power engineer, Hiram Walker and Sons, Inc., Peoria, Ill., has been named power engineer. Mr. Pfeiffer graduated from the University of Illinois in 1933 and joined Hiram Walker in 1934 as results engineer.

Hisagoro Mori (M '51), vice-president, Kansai Electric Power Company, Tokyo, Japan, was honored by Gilbert Associates, Inc., Reading, Pa., at a luncheon during a recent trip. Mr. Mori was in Reading for conferences in regard to economic and engineering problems relative to the construction of a power plant to be built in Japan.

J. J. Klosin (AM '48), sales engineer, James R. Kearney Corporation of St. Louis, Mo., Yonkers, N. Y., has been named manager of the utility division, Thomas and Betts Company, Inc., Elizabeth, N. J. Mr. Klosin has previously been associated with Kearney and with Burndy Engineering Corporation as a field engineer. He is a graduate of Catholic University of America.

R. W. Lundquist (AM '51), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named sales representative at the general machinery division Newark, N. J., district office. Mr. Lundquist is a graduate of Michigan State College and joined Allis-Chalmers in 1950.

D. C. Switzer (AM '45), relay engineer, Hartford (Conn.) Electric Light Company, has been named assistant to the superintendent of engineering. Mr. Switzer joined the company's engineering staff in June 1948, and has served as relay engineer. He is a graduate of Rochester Institute of Technology and formerly served with the New York State Electric and Gas Company, Ithaca, as substation electrician and designer.

J. H. Gerber (AM '46), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named sales representative at the general machinery division Milwaukee district office. Mr. Gerber has been with Allis-Chalmers since 1929, the last 7 years as an application engineer in the company's substation section. He is a graduate electrical engineer of Alabama Polytechnic Institute.

A. N. Goldsmith (M '15, F '20), consulting engineer, New York, N. Y., has been appointed editor of the Institute of Radio Engineers. **R. D. Bennett** (F '35), technical director, United States Naval Ordnance Laboratory, Silver Spring, Md., and **W. R. Hewlett** (AM '40, M '47), vice-president, Hewlett Packard Company, Palo Alto, Calif., have been appointed directors of the Institute of Radio Engineers for 1953.

H. W. Sussman (AM '36, M '45), Columbia Electric Manufacturing Company, Cleveland, Ohio, has been appointed general sales manager. Mr. Sussman joined Columbia as a student engineer in 1935, immediately after receiving his bachelor of science degree in electrical engineering from Case Institute of Technology and has held various positions in the engineering and sales departments. He is a member of the Association of Iron and Steel Engineers. He has served on the AIEE Sections Committee (1947–48).

Rose Feier (AM '51), assistant engineer, Technical Service Department, Burndy Engineering Company, Inc., Norwalk, Conn., has been elected a member of the Society of Women Engineers. A graduate of Hunter College, Miss Feier joined Burndy in 1942. She is a member of Phi Beta Kappa.

Abe Uretsky (AM '52), manager, Switchgear Engineering Department, English Electric Company of Canada, Ltd., St. Catharines, Ontario, has been appointed chief engineer of the company. Mr. Uretsky, a graduate in electrical engineering from the University of British Columbia, joined the company in 1940, working in the Engineering Department. He was made manager, Switchgear Engineering, in 1950, which post he will retain for the time being.

C. R. Pickens (AM '48), sales representative, United States Rubber Company, Charlotte, N. C., has been named southeastern division sales manager at Atlanta, Ga. **H. J. Cluver** (AM '34), district sales manager, Electric Wire and Cable Department, Philadelphia, Pa., has been appointed middle Atlantic division sales manager of the company, with headquarters at Philadelphia.

W. H. Smith (AM '52), Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named sales representative to the Pittsburgh, Pa., district office of the general machinery division. He is an electrical engineering graduate of Carnegie Institute of Technology.

A. H. Kuljian (AM '52), chief mechanical engineer, The Kuljian Corporation, Philadelphia, Pa., has been elected vice-president in charge of engineering. Mr. Kuljian is a graduate of Massachusetts Institute of Technology and is a member of The American Society of Mechanical Engineers and the Franklin Institute.

W. G. Hart, Jr. (AM '51), formerly from Oklahoma Agricultural and Mechanical College, Stillwater, has been appointed to the staff of the Gaseous Diffusion Plant, Oak Ridge, Tenn., operated by Carbide and Carbon Chemicals Company.

R. L. McDermott (AM '51) and **W. A. Giger** (AM '41, M '48), consulting engineer, Turbo Power Development Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., have been named application engineers at the Allis-Chalmers Norwood (Ohio) Works. Mr. Giger has had extensive experience in railway traction equipment in Switzerland and the United States. Mr. McDermott recently completed the Allis-Chalmers graduate training course.

J. A. Brown, Jr. (AM '50), application engineer, substation section, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named sales representative in the general machinery division Knoxville, Tenn., district office. Mr. Brown has been program chairman for the Milwaukee Section of the AIEE.

W. L. Healy (AM '51), technical service supervisor, General Electric Company, Philadelphia, Pa., has been elected president of the Standards Engineers Society for 1953.

T. K. Greenlee (AM '47), chief engineer, Barber-Colman Company, Los Angeles, Calif., has been appointed chief electromechanical engineer, Lear, Inc., Grand Rapids, Mich.

T. C. McFarland (AM '22, F '45), professor of electrical engineering and Chairman of the Division of Electrical Engineering, University of California, Berkeley, will relinquish the Division Chairmanship April 1, 1953. Professor McFarland was chairman of the San Francisco Section of AIEE during 1949–50. He is at present a member of the Committee on Education. He is a registered professional electrical engineer in the State of California.

OBITUARY

John Castlereagh Parker (AM '04, M '09, F '12, Member for Life), retired, vice-president, Consolidated Edison Company of New York, N. Y., and a past president of the Institute, died March 23, 1953. Mr. Parker was born in Detroit, Mich., April 15, 1879. He received a degree in mechanical engineering from the University of Michigan in 1901, a masters degree in 1902, and an electrical engineering degree in 1904. After an apprenticeship with the General Electric Company, Schenectady, N. Y., he was appointed an instructor in the electrical engineering department of Union College, Schenectady, under the late Charles P. Steinmetz. Later Mr. Parker was for 9 years a mechanical and electrical engineer with the Rochester (N. Y.) Railway and Light Company, and then for 7 years head of the department of electrical engineering at the University of Michigan, Ann Arbor, which, in 1940, made him a doctor of engineering. In 1922 Mr. Parker joined the Brooklyn Edison Company (now part of Consolidated Edison) as an electrical engineer. Later, as a vice-president, he had charge of all the company's engineering. After serving as president of Brooklyn Edison from 1932 to 1936 he took a position with Consolidated Edison as vice-president. In World War II he was a consultant to the War Production Board and organized the Office of War Utilities under the Office of Production Management. He also was a consultant to the War Manpower Commission and the Foreign Economic Administration and took an important part in the World Power Conference. He retired in 1949 as vice-president in charge of the departments of research and development. Mr. Parker was a member of the American Society of Civil Engineers and The American Society of Mechanical Engineers. An extremely active member of the AIEE, Mr. Parker had served as president (1938–39), vice-president (1921–22), and on the following Institute committees: Educational (1919–22, Chairman 1919–20); Meetings and Papers (1919–20); Technical Program (1939–40); Sections (1920–22); Student Branches (1919–20); Standards (1923–35, 1926–32); Electrical Machinery (1924–27); Power Generation (1924–26); Power Transmission and Distribution (1924–26); Lamme Medal (1931–34, 1944–47, Chairman 1945–47); Edison Medal (1938–41); Executive (1938–41, Chairman 1938–39); Planning and Co-ordination (1939–41, Chairman 1939–40); Basic Sciences (1940–41); and on numerous joint committees with other societies.

Framroze Nusserwanji Mowdawalla (AM '23, M '32), Bombay, India, died February 7, 1953. Mr. Mowdawalla was born in Bombay, December 26, 1889. He received his master of arts degree from the University of Bombay and his bachelor of science degree in mathematics there in 1911, after which he joined the Indian Institute of Science at Bangalore. In 1915 he received its associateship in electrotechnics. From 1916 to 1918 he was assistant to the professor of electrical engineering, College of Madras,

Madras, and for the next 2 years was assistant engineer, Tata Engineering Company, Ltd., Bombay. He was with Metropolitan Vickers Electrical Company, Ltd., Bombay, from 1921 to 1922 and later was assistant executive engineer, Lloyd Barrage Construction Works, Sukkar. He served as professor of electrical technology, Indian Institute of Science, for 2 years, and then was employed first by the government of Punjab and later by the government of Madras as executive engineer. After serving as head of the department of electrical technology, Indian Institute of Science, he was employed by the Mysore Government first as principal and professor of electrical engineering and then as chief electrical engineer. After this he worked as superintending engineer and deputy secretary to the government, North West Frontier Province. Mr. Mowdawalla was a member of the Institution of Electrical Engineers, Great Britain, and the Institution of Engineers, India. He was a foundation fellow of the National Institute of Sciences, India, and a fellow of the National Academy of Sciences.

Albert Joseph Kohler (AM '04, M '47, Member for Life), retired, Federal Power Commission, Washington, D. C., died February 1, 1953. Mr. Kohler was born in New York, N. Y., September 9, 1871, and was graduated from Cooper Union about 1891. For the first few years following his graduation he worked for various electrical concerns in Brooklyn, N. Y. He then went to Virginia and was superintendent of power for predecessor companies to Appalachian Electric Power Company in Lynchburg from 1900 to 1917. Following that, he was with the Pennsylvania Power and Light Company, Wilkes-Barre, from 1917 to 1925. During the period 1925 to 1929 he was engaged in construction work mostly on high-voltage lines for A. E. Fitkin Company in Arkansas, Pennsylvania, New York, and New Jersey. Mr. Kohler worked for the Trojan Engineering Company in New York City from 1929 to 1932. He was employed by the District of Columbia on engineering work from 1932 to 1935 and for the Public Works Administration in Elmira and Brooklyn, N. Y., from 1939 to 1941. At that time he joined the engineering staff of the Federal Power Commission where he continued until his retirement on March 1, 1950. Mr. Kohler was a member of The American Society of Mechanical Engineers.

George Edward Heidenreich, Sr. (M '28, F '50), electrical engineer, Cincinnati (Ohio) Gas and Electric Company, died February 5, 1953. Mr. Heidenreich was born in Cleveland, Ohio, February 26, 1895, and received his electrical engineering degree from the Case Institute of Technology. Following his graduation he served as a first lieutenant in the army in World War I. From 1919 to 1922 he was an assistant engineer with Warren D. Spengler Inc., Cleveland, and in 1923 he was employed by Aurora, Elgin and Chicago Railroad Company, Aurora, Ill. He joined the Union Gas and Electric Company, Cincinnati, in 1924 and supervised construction of power units. From 1925 to 1944 he was with Columbia Engineering Corporation. He had been with Cincinnati Gas and Electric since 1944. Mr. Heidenreich was a member of the National Society of Professional Engineers, Engineering Society of Cincinnati, and Ohio Society of Professional Engineers.

Samuel Charles Wilkerson (AM '34, M '50), superintendent of power, Alcoa Power Division, Aluminum Company of America, Calderwood, Tenn., died February 14, 1953. Mr. Wilkerson was born in Morrilton, Ark., November 4, 1889, and graduated from the University of Arkansas in 1911 with a bachelor of electrical engineering degree. From 1911 to 1913 he was electrical engineer for Mexican Light and Power Company, Nexaca, Puebla, Mexico, and from 1913 to 1916 was electrical superintendent, Mexican Northern Power Company, Santa Rosalie, Chihuahua, Mexico. He worked on various power developments in Arkansas and Ohio from 1916 to 1919. From 1919 until his death, Mr. Wilkerson was employed with the Aluminum Company of America or subsidiary companies. He worked in various capacities in British Guiana, Bauxite, Ark., Tapaco and Santeetlah, N. C., and Calderwood, Tenn.

Roy James Wensley (AM '28, M '35), chief engineer, South Bend (Ind.) Controller Company, died January 15, 1953. Mr. Wensley was born in Indianapolis, Ind., May 5, 1893, and was with Westinghouse Electric Corporation, East Pittsburgh, Pa., from 1916 to 1935. From 1935 to 1946 he was with I-T-E Circuit Breaker Company, Philadelphia, Pa., as assistant general manager and later general manager in charge of manufacturing operations. He was general manager of Wilcox-Gay Corporation, Charlotte, Mich., for a period before joining the predecessor company of Commonwealth Associates Inc., Jackson, Mich., in 1948. In 1950 he went to Turkey to make an engineering survey in connection with the Economic Co-operation Administration and later that year joined South Bend Controller Company. Mr. Wensley was a member of the Institute of Radio Engineers.

Raymond Bartlett Wendell (AM '11, M '32, Member for Life), retired, Homewood, Ill., died November 12, 1952. Mr. Wendell was born April 30, 1886, in Chicago, Ill., and was graduated in electrical engineering from Armour Institute of Chicago. He was employed in various electrical operating and engineering capacities by the Public Service Company of Northern Illinois during his whole career. At the time of his retirement, May 1, 1951, he held the position of design engineer in the Electrical Engineering Department in the Chicago office. Mr. Wendell was a member of the Western Society of Engineers.

Raymond Joel Andrus (AM '08, M '21, Member for Life), utility consultant, Pacific Palisades, Calif., died January 23, 1953. Mr. Andrus was born September 26, 1884, in Rockford, Ill., and graduated from the University of Minnesota in 1907 with an electrical engineering degree. Mr. Andrus had been associated with several utility com anies in Minnesota as an electrical engineer.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of March 19, 1953, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Anderson, H. C., Jr., electrical engineer, General Electric Co., Schenectady, N. Y.
Binder, A. A., asst. mgr., apparatus products div., Westinghouse Electric International Co., New York, N. Y.
Bridegam, W. J., electrical test engineer, Gilbert Associates, Inc., Reading, Pa.
Burpee, W. E., electrical engineer, Badger Process Div. of Stone & Webster Engineering Corp., Boston, Mass.
Caldwell, S. E., planning engineer, Portland General Electric Co., Portland, Oreg.
Cruikshank, M. T., engineer, The Bell Telephone Co. of Pennsylvania, Pittsburgh, Pa.
Duchastel, P. A., superintendent, engg. dept., Quebec Power Co., Quebec, Quebec, Canada
Duffy, F. H., asst. mgr. of power generation, Aluminum Co. of Canada, Ltd., Shipshaw, Quebec, Canada
Farrell, R. J., control engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Gall, J. R., The Esterline-Angus Co., Inc., Indianapolis, Ind.
Gow, R. B., design engineer, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Hartmann, W. A., Jr., project engineer, Bendix Aviation Corp., Teterboro, N. J.
Jenner, W. C., research engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Johnson, W. J., branch engineer, testing div., Philadelphia Electric Co., Philadelphia, Pa.
Kammer, K. P., electric production supt., New Orleans Public Service Inc., New Orleans, La.
Moncher, F. L., project engineer, Vickers Incorporated, Detroit, Mich.
Ohrn, C. T., transmission & distribution supt., Cape & Vineyard Electric Co., Hyannis, Mass.
Pashby, R. W., asst. to vice-pres., Micro Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.
Percival, D. R., manager, Machinery Electrification Inc., Worcester, Mass.
Schroeder, A. F., partner, Buell & Winter, Engineers, Sioux City, Iowa
Smith, G. L., engineer, Southern Services, Inc., Birmingham, Ala.
Stanger, E. A., asst. general manager, Southern Canada Power Co., Ltd., Montreal, Quebec, Canada
Strassmeyer, A. H., electrical engineer, The Austin Co., Cleveland, Ohio
Swift, Lionel, superintendent, power div., Quebec Power Co., Quebec, Quebec, Canada
Swoish, W. R., vice-pres. & sales manager, Pennsylvania Transformer Co., Canonsburg, Pa.
Welch, T. R., president, Neomatic, Inc., Los Angeles, Calif.
Werts, R. W., division engineer, Metropolitan Edison Co., Reading, Pa.
Wessling, J. R., vice-pres., Electric Supply Corp., Chicago, Ill.
Wright, W. D., toll circuit & transmission engineer, Indiana Bell Telephone Co., Indianapolis, Ind.

29 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before May 25, 1953, or July 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico

To Grade of Member

Beyerle, W. P., Jr., Consolidated Gas & Elec. Co., Baltimore, Md.
Fiuczek, Z. K., Elec. Dept., City Council, Singapore, Straits Settlements
Gano, J. J., Massachusetts Institute of Technology Digital Computer Lab., Cambridge, Mass.
Garner, E. M. F., The India Jute Co., West Bengal, India
Sauer, H. O., Delta Star Electric Co., Chicago, Ill.
Stoddart, T. W. H., Rogers Majestic Electronics, Ltd., Toronto, Ontario, Canada

6 to grade of Member

IBM "701" Electronic Calculator Is the First Designed for Quantity Production

Installation of the first production model of International Business Machines' (IBM) newest and most powerful high-speed electronic calculator, the "*701*," at the company's World Headquarters, New York, N. Y., was announced recently.

Designed to shatter the time barrier confronting technicians working on vital defense projects, the *701* is being manufactured in IBM's Poughkeepsie, N. Y., plant, where production-line techniques of assembly and standardization are used.

Composed of 11 compact and connected units known as IBM Electronic Data Processing Machines, the *701* is the first calculator of comparable capacity to be produced in quantity. A dozen or more will be built this year, all consigned to government agencies or defense industries.

The calculators will be used for the calculation of radiation effects in atomic energy; for aerodynamic computations for airplanes and guided missiles, including vibration and stress analysis, design and performance computations for jet and rocket engines, propellers, landing gear, radomes, and so forth; on studies related to the effectiveness of various weapons, and on steam and gas turbine design calculations. A company which has pioneered the use of high-speed digital computers for cost accounting with the IBM Card-Programmed Electronic Calculator, will use the *701* to speed and simplify the immense task of assembling and interpreting production cost data from its several plants. In government agencies the *701* will be used principally on restricted problems.

The *701* installed at IBM in New York will be operated as a Technical Computing Bureau for organizations having problems involving mathematical computations. These will include problems similar to those listed, as well as geophysical calculations and commercial studies. Test computations now in progress include a problem relating to the electronic charge distribution in the nitrogen molecule.

In preparation for the use of this machine by American industry, a staff of IBM scientists has been engaged for 2 years in planning the economical solution of typical problems. One result of this work is that users of the machine no longer need be concerned with tracing the position of the decimal point through problems involving thousands or millions of sequential arithmetical steps.

Using a "floating point" technique the machine notes the position of the decimal point in the input numbers, keeps track of the point, and finally reports the position the decimal point as the results are printed.

So much progress has been made in ea of use of electronic computers that in course of only 3 weeks' duration, IBM is ab to instruct its Technical Computing Burea users in the preparation of problems for th *701* and operation of the machine.

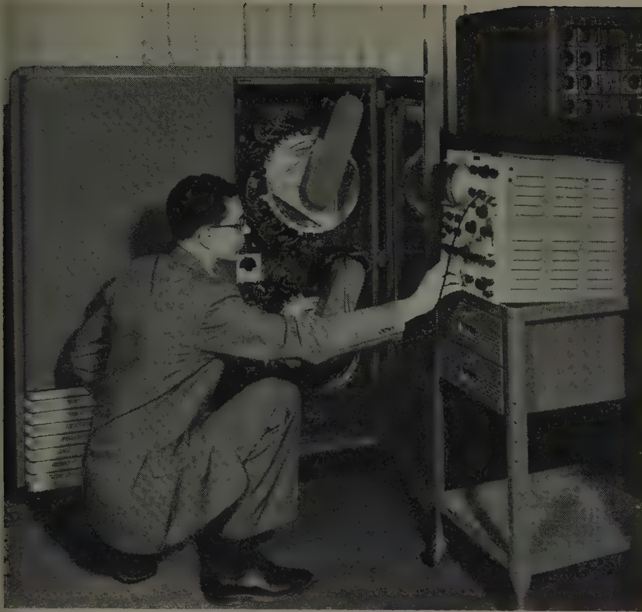
The *701* has at least 25 times the over-a speed but is less than one-quarter the size IBM's Selective Sequence Electronic Calcu lator (SSEC), which was dismantled make room for its speedier successor.

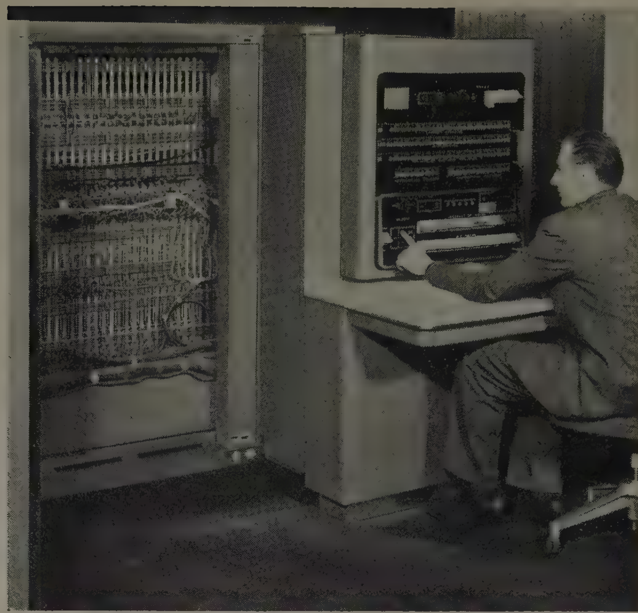
During its 5-year reign as one of th world's best-known electronic brains, th SSEC solved a wide variety of scientific an engineering problems, some involving man millions of sequential calculations.

Though the *701* occupies the same qua ters as the SSEC, which it rendered obsolet it is not built into the room as was its pred cessor. Instead, it is smartly housed b tween serrated walls of soft-finished alum num. A balconied conference room, ove looking the calculator and separated from by sloping plate glass, provides a vantag point for observing operations and discussin computations. Ample space is provided fo writing the complex and abstract equatior that are the stock in trade of engineers an scientists in an age of atomic energy an supersonic flight.

The *701* uses all three of the most advance electronic storage or memory devices cathode-ray tubes, magnetic drums, an magnetic tapes. The computing unit us

In the center of the units of the 701 calculator, above, is the Electronic Analytical Control Unit, and at its right is a Card Reader. Be hind the control unit is the Power Distribution Unit. On the left are the Magnetic Drum Storage Unit and the Electrostatic Storag Unit. In the group at the right are two Magnetic Tape Readers and Recorders, the Alphabetical and Numerical Printer, and th Card Punch. In this installation, the two Power Supply Units are not visible. Overlooking the calculator is a glass-enclose conference room





(Above left) The two drums in the Magnetic Drum Storage Unit which store more than 80,000 digits. The reading and writing heads read and write magnetized spots of data while the drum spins. (Above right) Control center where indicator lights on panel enable operator to determine at a glance exact phase of work processed. Computing and control section of unit is open, revealing part of the intricate wiring. (Right) Magnetic tapes introduce or record data at rate of 12,500 digits a second and have capacity of 2,000,000 digits a tape. Each of the two Magnetic Tape Readers and Recorders handles two reels of tape simultaneously

small versions of the familiar electronic tubes, which are able to count at millions of pulses a second. In addition, several thousand germanium diodes are used in place of vacuum tubes, with resultant savings in space and power requirements.

The *701* was designed for scientific and research purposes, and similar components are adaptable to the requirements of accounting and record-keeping. Research on commercial data processing machines is under way.

The *701* is capable of performing more than 16,000 addition or subtraction operations a second, and more than 2,000 multiplication or division operations a second. In solving a typical problem, the *701* performs an average of 14,000 mathematical operations a second.

Internally, the *701* performs operations in the binary number system. All initial data and final results may be in the familiar decimal number system. High-speed conversion between number systems is handled automatically by the calculator.

But speed alone is not enough. To be able to solve the problems of enormous mathematical complexity attending the defense effort, a computer also must have prodigious storage capacity and extreme flexibility. Further, it must have input and output systems that are both fast and efficient.

The new computer can solve problems involving partial differential equations, ordinary differential equations, integral equations, matrices, and combinatorial analyses. Partial differential equations occur, for example, in calculating the rate of flow of heat in the skin of a supersonic missile; ordinary differential equations arise in calculating the expected flight characteristics of the missiles; integral equations arise in calculating radiation intensities; matrices arise in component analyses in petroleum products, and combinatorial analyses arise in strategic and tactical considerations.

The need for an electronic machine which will carry out thousands of operations a second is illustrated by the fact that the solution of a well-known partial differential equation useful in aircraft wing design requires 8,000,000 calculating steps per case.

The solution must be carried out step by step. Thus step 100 cannot be computed until the result of step 99 is known. Consequently, only one man, working with pencil and paper or one machine, can be occupied with the problem at any one time. The *701* completes the solution in a few minutes. A man working with a desk computer and using the same method would require 7 years.

The banks of cathode-ray tubes in the *701*, known technically as electrostatic storage units, comprise the heart of the machine through which all information to and from all other components must pass.

The tubes—each resembling a smaller version of the picture tube used in television sets—can store the equivalent of 20,000 decimal digits on their screens by means of the presence or absence of charged spots. In a few millionths of a second, any digit stored on a tube screen can be selected for use, with a scanning electronic beam "reading" the charges and converting them into electronic pulses. These pulses are interpreted as numbers or calculating instructions.

The computer's magnetic drums, swiftly spinning cylinders surfaced with a material which can be magnetized easily, can store the equivalent of 80,000 decimal digits, any of which are available for use thousands of times a minute.

The magnetic tapes used in the *701* are similar in appearance to those employed by home sound recorders. In the new computer, each reel of tape can store 2,000,000 digits. Since fresh tapes can readily be substituted for those "filled" with digits, magnetic-tape storage in the *701* is unlimited, for all practical purposes.

Components of the *701* include an Elec-

tronic Analytical Control Unit, an Electrostatic Storage Unit, a Punched Card Reader, an Alphabetical Printer, a Punched Card Recorder, two Magnetic Tape Readers and Recorders (each including two magnetic tapes), a Magnetic Drum Reader and Recorder, and units governing power supply and distribution.

A typical problem is handled in this way:

All pertinent numbers, representing both the digits to be processed and instructions as to the procedure to be followed, are fed into the computer and automatically transmitted to the Electrostatic Storage Units.

The instant the machine has the data necessary to solve the problem it begins computing. This is done by the arithmetic and control circuits of the Analytical Control Unit, which take numbers from the Electrostatic Storage Units according to instructions and perform any combination of arithmetic operations desired.

By means of the instructions provided the machine prior to the start of computing operations, the control circuits will make decisions as to the steps required to complete the solution of the problem without intercession by the operator.

When the computing is completed, step by step, the results are stored back in the Electrostatic Storage Units. If so directed in the preliminary instructions, the machine will then print the results on sheets of paper by means of a 150-line-a-minute printer at the rate of 1,050 10-digit numbers a minute. For compact storage and high-speed input and output, the *701* will transmit results to magnetic tapes at a rate equivalent to 1,250 10-digit numbers a second. Also if desired, the machine will punch the results in standard punched cards at a rate equivalent to 2,400 10-digit numbers a minute.

In the case of problems involving more digits than can be conveniently stored in the Electrostatic Storage Units, the figures and calculating instructions are stored on the magnetic drums and tapes. When these are needed for use by the arithmetic circuits, they are automatically transmitted to the electrostatic memory components and the operation proceeds as outlined in the foregoing.

The *701* will be rented to users for approximately $12,000 monthly. The company will install the *701* in a plant and furnish a trained crew to operate and maintain the computer. Businesses may also bring their problems to IBM for solving by the *701*.

Future Meetings of Other Societie

American Association of Spectrographers. Syn posium on Emission Spectroscopic Determination Metals in Non-Metallic Samples. May 1, 195 Chicago, Ill.

American Society for Quality Control. 7th Annu Convention. May 27–29, 1953, Convention Ha Philadelphia, Pa.

Compressed Air and Gas Institute. May 4–6, 195 King and Prince Hotel, St. Simons Island, Ga.

Edison Electric Institute. 21st Annual Conventio June 1–4, 1953, Atlantic City, N. J.

Electric Association and Electrical Maintenan Engineers. Chicago Electrical Industry Show. Ma 11–14, 1953, Conrad Hilton Hotel, Chicago, Ill.

Engineering Institute of Canada. 67th Annual Co vention. May 20–23, 1953, Dalhousie Universit Halifax, Nova Scotia, Canada

Heat Exchange Institute. May 11–13, 1953, Th Greenbrier, White Sulphur Springs, W. Va.

Hydraulic Institute. May 25–27, 1953, Seavie Country Club, Absecon, N. J.

Institute of Radio Engineers. National Conference o Airborne Electronics. May 11–13, 1953, Dayto Biltmore Hotel, Dayton, Ohio

Material Handling Institute. 5th National Materia Handling Exposition. May 18–22, 1953, Conventio Hall, Philadelphia, Pa.

National Industrial Service Association. 20th Ann versary Convention. May 24–28, 1953, Hotel Statle New York, N. Y.

Operations Research Society. Annual Meetin May 15, 16, 1953, Case Institute of Technology, Clev land, Ohio

Society of Photographic Engineers. 3d Annu Conference. May 20–22, 1953, Hotel Thayer, We Point, N. Y.

Society of the Plastics Industry. Annual Meeti and Conference. May 9–15, 1953, Cruise to Bermu

The American Society of Mechanical Engineers, C and Gas Power Division. 25th Annual Conferen and Exhibit. May 25–28, 1953, Schroeder Hot Milwaukee, Wis.

Automatic Teletype System Handles Air-Line Communications Operations

A new completely automatic teletype system designed to handle the heavy volume of communications necessary in the operations of a modern air line has been announced by American Airlines and the Long Lines Department of the American Telephone and Telegraph Company.

The system, called the *81-D-1*, is the only one of its kind, featuring automatic switching among circuits, automatic priority to urgent messages, and automatic push-button addressing of air-to-ground messages.

The system links American's 70 stations on its nation-wide routes.

Its importance to American is evident in the monthly volume of messages transmitted. American made a total of 571,000 teletype transmissions over its private-line system in the month of February. The volume averages about the same each month.

The new system supplants a network of teletype circuits along American's routes. Under the old system, the operator, before transmitting a message, watched the circuit and awaited his turn in station sequence. This was necessary to preserve order and permit each station equal opportunity for transmission.

A priority message allowed the operator to "break" the circuit, that is, stop all other transmissions and send the priority message immediately. A large number of priorities at one period not only disrupted normal sequence but delayed regular messages.

Every machine on a circuit received a copy of every message transmitted on that circuit. Consequently, at every machine someone scanned the address of each message to determine whether that location was in the address. If not, the message was discarded. If discarded in error, a "lost" message r sulted.

Courtesy American Airlines

Radio operator in dispatcher's office routes message he has recorded on the Teletypewriter

Certain stations were designated as rela stations, and at these stations messages we manually transferred from one circuit another.

It is obvious that much time was spe waiting for station sequence, scanning messa addresses, and manually transferring pe forated tape from one circuit to anothe Priority "breaks" added to the delays. T waste of teletype paper was enormous due the discarding of received messages a dressed to other stations. Each operatio presented chances for human error.

The new *81-D-1* Private Line Telety (PLT) System also has a number of statio on each circuit. However, each circu terminates in one of three automatic switc ing centers at New York, N. Y., Chicag Ill., and Fort Worth, Tex.

The circuits are "duplexed." That they allow simultaneous transmission in ea direction. Messages are passed betwe switching centers over duplexed trunk lin

A message transmitted from one circu addressed to a station or stations on its own another circuit, comes into the switchi center and is automatically transferred "relayed" to outgoing circuits on which t stations addressed are connected.

Only the stations addressed receive a co of the message. A message can be sent (

Courtesy American Airlines

Switching center units handle traffic for circuit. Each set of units has four tape perforators, one for traffic coming into the switching center from the circuit, two to handle traffic from other circuits to the circuit, and one for priority messages

to any one of the 150 machines in the 70 stations; (2) to any specified group of these machines; or (3) to all. This selectivity of the system is accomplished by assigning each of the 148 receiving machines a 2-letter CDC (Code Directing Characters) which automatically starts that particular machine. This feature alone will save American about $2,500 a month in paper since it eliminates the unnecessary duplication of messages.

The word automatic means more than just the relay of messages. Messages to be sent are automatically transmitted in sequence on each circuit. No longer does the operator have to sit at his machine waiting his turn in station sequence.

Here is how it works: An originated message with its CDC is typed out on the teletype machine and a tape is perforated. The tape is inserted in the teletype transmitter head just as with the old system. The operator, however, can now leave the PLT machine, for the tape will be transmitted automatically when the machine's turn in circuit sequence is reached.

There is no loss of time by the operator waiting his turn to transmit, no loss of time in scanning, no waste of paper in discarding unwanted messages, no manual relay of tape in the switching centers. The chances for error in operation are reduced to a minimum.

Even in case an error is made in the addressing of a message, the *81-D-1* is geared to catch it. The incorrectly addressed message, on reaching the switching center, is relayed to an intercept machine and held until the address is corrected.

The intercept also comes into play when a station is out of order or closed down for maintenance. All messages to such a station are relayed to the intercept until such time as the station goes back into operation.

Although several other air lines have automatic PLT switching systems, the *81-D-1*, developed over several years in the Bell Telephone Laboratories to meet the needs of American Airlines, has some special features which make it the only one of its kind.

One feature is the automatic push-button addressing of aircraft radio contacts to flight control points and to other stations concerned. Radio operators at primary stations copy air-to-ground contacts directly on teletype machines. After contact is completed, the operator, knowing the station or combination of stations that should receive the information, presses one of a series of buttons beside his machine. Pressing the button causes the proper address to be automatically inserted ahead of the contact text just typed.

Without further attention from the operator the contact is transmitted in proper circuit sequence.

All air/ground radio contacts receive priority handling on teletype, and the *81-D-1* has an automatic priority system which makes it unique. Priority messages are assigned a special code and are "stored" on a special level in the switching center units.

When an electric impulse, called a start pattern, is sent from the switching center to "search" the stations, it picks up the priority messages from all stations before the regular traffic is taken from the stations in turn.

At the switching center, priority messages, assigned the special code and "stored" on a special level, are released before the regular traffic. The start pattern is automatically sent and all messages automatically released.

To insure uninterrupted communication, a station receiving a start pattern automatically either releases its traffic or sends a positive signal that there is none. If neither a message nor this signal is received an alarm signal is given and the trouble is attended to immediately.

Internal Magnetic Focus Gun Provides Sharper Television Picture Definition

Development of an "internal magnetic focus" gun which will permit the elimination of the external focus coil and ion trap magnet on television picture tubes was announced by the General Electric Company's Tube Department recently.

Use of the gun will also make possible sharper picture definition across the entire face of television screens.

Company engineers predicted that the elimination of the necessity for television receiver manufacturers to add a focus coil, ion trap, or bulky mounting brackets to picture tubes will mean a major saving in parts and assembly operations.

The new gun contains an internal compensating focusing lens which maintains focus over a wide range of operating voltages. A simple shunt may be used to increase this range. No external focusing control requiring adjustment by the set owner is necessary.

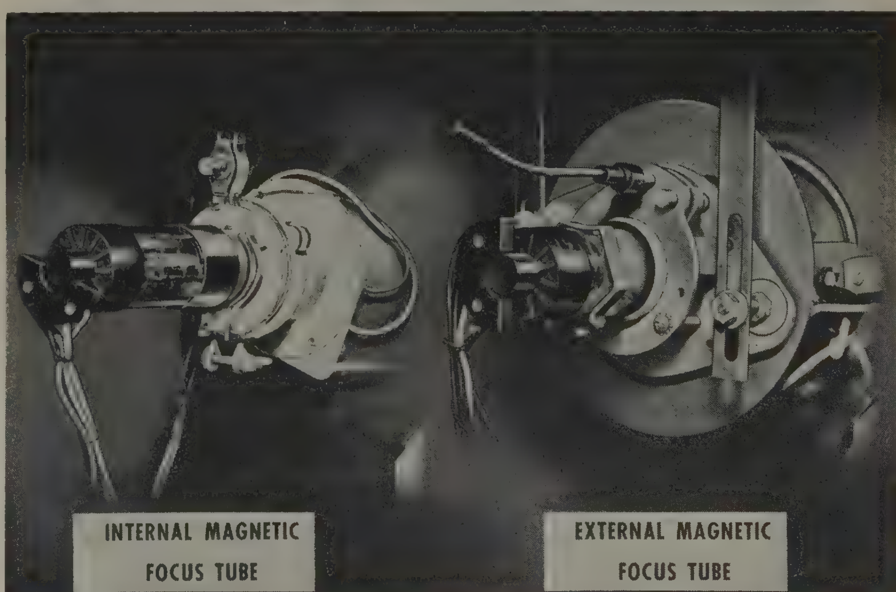
General Electric placed a 21-inch tube, the *21JP4*, which incorporates the new gun, on display and announced that it has immediate plans for adding additional internal magnetic focus tubes to its line of cathode-ray television picture tubes.

The basic gun design used for the television-picture-tube gun also can be applied to cathode-ray tubes for radar, industrial television, or studio monitor equipment. The gun eventually may be designed into tubes which can be used as replacements for tubes now in use.

The tubes using the new gun will have all the advantages of magnetic focusing and none of the disadvantages or costs associated with present magnetic focus tubes.

Variations in picture-tube anode voltage will not affect the quality of the picture focus as much as it does with present magnetic tubes. The gun will provide a clear focus over the entire face of the screen within the rated anode voltage range.

The focusing and ion trap devices in the



Simplicity of installation of an internal magnetic focus system for television picture tubes, left, is contrasted with external magnetic focusing installation, right. The new internal magnetic focus gun is designed to provide sharper picture focus, as well as to make possible elimination of certain parts used in focusing system

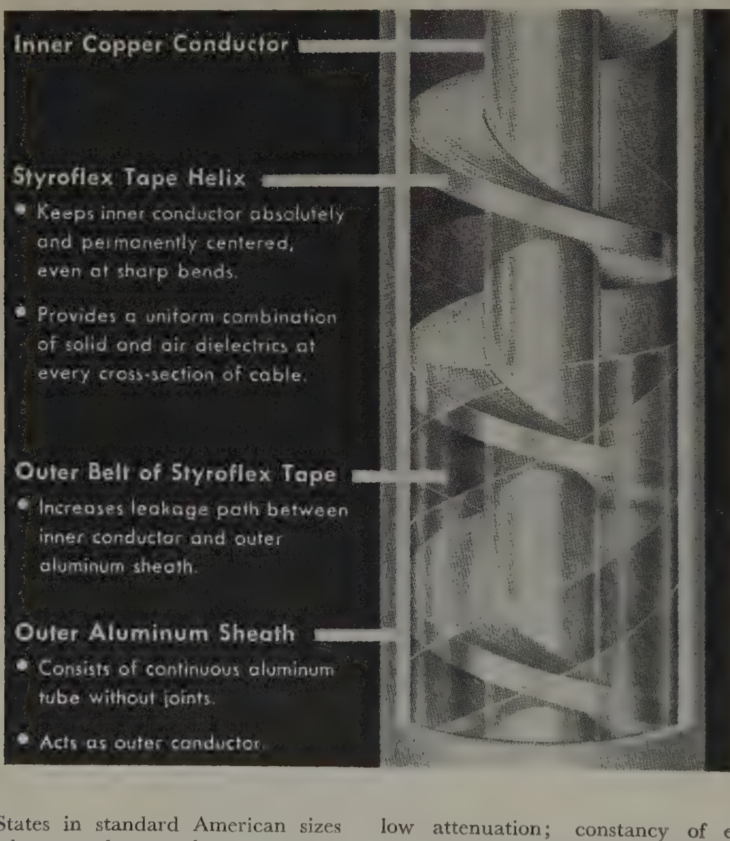
new gun employ four tiny Carboloy "Alnico 5" magnets made of the most powerful permanent magnetic material now being produced. Three of the Alnico magnets, measuring 1/4 inch in diameter and 5/8 inch in length, are used in the focus assembly and the fourth, measuring 1/8 inch in diameter and length, is used in the ion trap unit.

The *21JP4*, first tube in which the new gun has been incorporated, is a 21-inch rectangular cylindrical-face tube with a 70-degree deflection angle.

Styroflex Coaxial Cable Meets Demand for High-Power Low-Loss Broadcast Cable

Semiflexible, aluminum-sheathed Styroflex cable, made by Phelps Dodge Copper Products Corporation, is designed specially to meet the need for a high-power, efficient low-loss coaxial cable in the amplitude-modulation, frequency-modulation, television, and microwave fields. The cable reduces reflections, which cause ghost images in television and distortions in communications, to an absolute minimum.

The cable was developed by Felten and Guilleaume Carlswerk of Cologne, Germany, which has made many successful installations of the cable throughout Europe. Phelps Dodge is making the cable for sale in the United States in standard American sizes and impedances under a working agreement with the Cologne firm. The cable is manufactured in continuous 1,000-foot lengths, without joints.



Outstanding feature of the cable is the use of insulating Styroflex film to form a helix. This helix, built up of hundreds of precision-wound Styroflex tapes, firmly supports and centers the inner conductor coaxially in an aluminum sheath at all times, assuring retention of excellent electrical properties.

Styroflex is a unique flexible form of polystyrene, characterized by the excellent electrical properties of styrene: dielectric constant 2.5, power factor 0.0002. No plasticizer is employed to achieve flexibility, this property being obtained by special manufacturing techniques. The lack of plasticizer assures constancy of the high tensile and compressive strengths of the Styroflex film. Styroflex does not cold flow.

The inner conductor consists of a solid copper or copper-clad wire or a copper tube. This is coaxially supported in a homogeneous aluminum tube by means of the Styroflex tape helix.

Outstanding features of this cable are inner conductor absolutely and permanently centered; no radiation; no standing waves; low attenuation; constancy of electrical properties regardless of mechanical shock, ambient temperature variations, or load cycling; high cutoff frequency, with flat characteristics at all frequencies below; ease of handling due to semiflexibility; light weight; high strength, enabling self-support; adaptability to manufacture in wide variety of diameters; and no pressurization needed.

The high strength helix continuously anchors the inner conductor relative to the outer, through temperature cycling, and maintains a continuously uniform electrical characteristic throughout service life.

(*See also EE, Jul '50, p. 648.*)

New Device Enables Aircraft to Fly Without Human Aid

A new device developed for the Unit States Air Force which enables an aircraft take off, fly on a prescribed course to a giv destination, and then land—all without human hand's touching the airplane's co trols—was announced jointly by Minneap lis-Honeywell Regulator Company and t Air Research and Development Comman

The development was described as anoth step toward completely automatic flight. opens the way, the company said, to aut matic long-range flights from coast to coa and, while not intended for intercontine travel, could be employed for similar fligh spanning the oceans.

A. M. Wilson, vice-president in charge the company's aeronautical division, said t principles involved in the development al offered great potential for use in automa cally controlling manufacturing operations industry.

The device, a highly intricate electr "brain" called an Automatic Master S quence Selector (AMSS) was developed Honeywell's aeronautical research enginee in co-operation with the Wright Air Develo ment Center of the Air Research and D velopment Command. It operates on t familiar punched-tape principle to progra the functions of the autopilot and the ai speed control. When used with this oth electronic equipment, the "brain" forms robot "pilot" which practically places t human pilot in a monitoring role througho an entire flight.

The "brain" takes over many of the duti normally performed by a human pilot "memorizing" a flight plan from punche tape, and then converting information from myriad of instruments, sensors, compute and navigational aids into electric impuls that go to the plane's autopilot and airspee systems to carry out the plan.

"In other words," said Hugo Schuc Honeywell's aeronautical research directo "what we've designed is a master controll of the plane's controls. The Sequen Selector takes information from the punche tape and automatically converts it in orders to the plane's controls, to make t plane fly the way we want it flown, and to where we want it to go, according to a pla worked out in advance."

While this adds up to virtually comple automatic flight, Schuck emphasized that t development is not aimed at eliminating t human pilot.

"Instead," he said, "the aim is eliminati of the routine from flight operation, th freeing the human pilot to be the captain the ship in the true sense of the word. T one thing that robots still can't do is thin So, in actual operation of the Sequen Selector, the plane will be flown automa cally but a pilot will be in charge to exerci judgment and take over manual control the plane when necessary or desirable."

The AMSS, Schuck said, represents significant advance in long-range planni for the day when automatic control a scheduling of aircraft will be necessary flight navigation.

"With the complexity of aircraft increasi at a terrific rate," he explained, "and wi congestion already a serious problem many of the nation's strategic airports,

are fast approaching a new concept in flight operations.

"Under this concept, a plane won't take off until it has clearance all the way through from take-off to landing. What this presupposes is that a plane won't take off until there is a slot for it at its destination.

"Such operation will demand the utmost in precise scheduling and navigation. If planes have to come in for landings on flight schedules that are timed right to the second, we won't be able to depend upon human pilots who, no matter how good they are, still can make mistakes. It will have to be done with robots such as the Automatic Master Sequence Selector."

A plane under control of the AMSS will take off, climb to a given altitude, assume a predetermined heading, or series of headings and altitudes; fly along a radio beam or other course to its destination in a given length of time, and then land.

Here's how the robot works: A flight plan is made out in advance. The plan is divided into sequences; that is, one sequence for taxiing down the runway, another for take-off, a third for climbing after the plane is air-borne, and so on. This flight plan then is punched into tape by means of a special coding device developed by Honeywell for use with the AMSS.

In operation, the punched tape is fed through the AMSS in much the same manner that music rolls were run through the old-fashioned player piano, except that the motion is intermittent—one sequence at a time.

The robot's complex mechanism including more than 1,000 parts and several miles of wiring, is housed inside a cabinet about the size and shape of a large table-model television set. Among the parts are 430 metal pins located in the sensing element.

As the tape moves through the AMSS, these metal pins drop down on it and, like the fingers of a blind person reading Braille, search out the punched holes. Where there are holes, the pins make electrical contacts, and these in turn are converted into signals that operate the plane's controls.

The device is designed so that a human pilot aboard can keep tab on the over-all progress of the flight at all times. It is also designed so that he can take over manual control instantly, should he desire to because of an emergency, such as mechanical failure or unforeseen obstacles in the flight path. Thus, if the plane ran into an unexpected storm, the human pilot would be able to take control, fly around the storm, return to the original course, and turn control back to the robot.

An engineering model of the AMSS already has been delivered to the Flight and All-Weather Testing Directorate at the Air Research and Development Command's Wright Air Development Center, Dayton, Ohio, for whom it was built, and is now awaiting flight test. It was this United States Air Force unit which made flight history in 1947 by flying a *C-54* across the Atlantic without human hands' touching the controls.

"The development of the Automatic Master Sequence Selector," Schuck said, "can be regarded as the next major step in automatic flight beyond that 1947 achievement. The scope of the equipment used in the 1947 flight was limited to a relatively few sequences, whereas the AMSS makes possible an unlimited number of sequences of control without duplicating the control equipment.

"This is done by introducing the concept of controlling the controller. In the AMSS, weight and complexity of equipment are also reduced, and many additional functions are introduced so that flight control can be more efficient."

College Engineering Enrollments Show Increase in New Students

"The almost unprecedented increase in the number of freshmen engineering students in 1952 (30.5 per cent) has been exceeded only once, and that was in the year immediately following World War II. The 51,631 new students entering in the fall of 1952 represent the third largest class ever to enter engineering schools. Exceeded only in 1946 and 1947, the number of new engineering students account for almost 16 per cent of all male students entering college for the first time in 1952. Assuming normal progression of the current entering class of engineering students, the resulting number of graduates in 1956 will be in the neighborhood of 30,000." So states the January 1953 circular titled, "Engineering Enrollments and Degrees, 1952," compiled under the auspices of the Federal Security Agency—Office of Education.

This survey which reports data supplied by 149 institutions offering curricula accredited by Engineers' Council for Professional Development and by 44 institutions in which no curriculum is so accredited, points out that the 20,469 engineering graduate students enrolled in the fall of 1952 represent an increase of 4.2 per cent over the preceding year.

While the graduation estimates for the next 4 years show no material deviation from those previously made, it is interesting to note an increased tendency on the part of students entering college toward engineering.

Ultraviolet Photometer Detects Minute Gas Concentrations

A sensitive and versatile instrument which can be used to detect minute concentrations of gases is the latest tool perfected by E. I. du Pont de Nemours and Company to aid in the control of atmospheric pollution.

The instrument, an ultraviolet photometer, operates by measuring the decrease in intensity of a beam of ultraviolet light when the contaminated atmosphere is allowed to pass through a transparent vessel mounted in the beam. A refinement of an instrument developed by Du Pont some 10 years ago, a new method of calibration and modifications of design have greatly extended its range of sensitivity.

The absorption of ultraviolet light has been used for many years as a method of chemical analysis. The chief problem arises from the high degree of sensitivity that is required. The ultraviolet light photometer can detect a decrease in light intensity amounting to one part in 10,000. By way of comparison, the human eye can detect a decrease in light intensity of one part in 100 and is thus 100 times less sensitive.

To put it another way, this degree of precision is equivalent to detecting at a glance the loss of two drops from a quart of milk or one lump from half a ton of nut coal. With this sensitivity, the instrument can detect concentrations of benzene, bromine, carbon disulfide, nitrobenzene, ozone, sulfur dioxide, and tetrachloroethylene, to name but a few that are well below the established industrial hygiene safety limits for 8 hours exposure.

The photometer is conveniently portable and can be used in any area where 110-volt electric power is available.

A difficult problem in the application of this analyzer or any analytical method for the detection of extremely low concentrations of gases, is the method of checking the calibration. The obvious method of mixing a small measured amount of the gas or vapor with a large chamber of air will frequently give erroneous results because of the tendency of many compounds to be adsorbed on the surfaces of solid materials.

A new method of calibration overcomes this problem through the use of a special gas-mixing apparatus by means of which samples of air containing known low concentrations of gases are prepared continuously. Continuous preparation of the mixture effectively eliminates errors due to the adsorption of the vapor.

Chalkboard Lighting Unit Gives Illumination Without Glare

The first significant improvement in the proper illumination of classroom chalkboards has been introduced by a Chicago manufacturer, Solar Light Manufacturing Company.

It is a chalkboard lighting unit that is designed especially to give maximum illumination from the top to the bottom of chalkboards, without any glare.

While tremendous improvements have been made recently in classroom illumination, the chalkboard has been pretty much overlooked.

It is not uncommon for a student seated at the rear of a classroom to be guessing much of the time as to what the instructor is putting on the board. This is because old-style lighting frequently aggravates the principal factors which contribute to low visibility; small detail, low contrast, distance, and subnormal vision.

As classrooms become larger and details on the board smaller, as in the case of technical subjects in high schools and colleges, this condition has become critical.

What is generally regarded as good, general illumination in the average room according to illuminating engineers, will normally provide less than half as much light at the chalkboard surfaces as on desk tops.

In addition, a letter that is 3/4 inch high on the board when viewed by a student seated 30 feet away from the board, will appear no larger than the same letter 1/32 inch high on the book page at the desk.

Further pointing to the need for the best possible illumination of the board is the fact that the contrast on the board is generally poorer than on a book at a desk, nor can the pupil take as much time for deliberation when reading a chalkboard as when reading a book.

Increasing the illumination on chalkboards assists the pupil to discern more

easily what is on the board. Increased illumination serves also to decrease the ratio between the board brightness and that of the adjacent wall.

Research has shown that a reduced brightness ratio, between chalkboard and the wall or background color, contributes to eye comfort. This is also one of the reasons for the trend toward chalkboards in pastel colors.

Herman Lazerson, vice-president of the Solar Light Manufacturing Company, said that the lighting development, called the "Chalkboard Dean," utilizes a parabolic trough reflector placed along the top of the board extending out from the wall. The inside of the reflector is highly polished and the outside can be painted the same color as the wall.

The light from a single row of fluorescent lamps is distributed over the entire board, from top to bottom, through scientific angling of the reflector.

The operating cost is low as only 175 watts is involved. Maintenance is also at a minimum as the reflecting surfaces are facing downward in a position to collect little dust or dirt. The tubes are shielded to 60 degrees from the classroom side, thus there is no brightness annoyance even to someone standing close to the board.

As the light comes from two directions there is no shadow of the hand as one writes on the chalkboard. The lamp and reflector are so arranged that the direct rays of the lamp illuminate the top of the board and the maximum output of the reflector is directed to the bottom of the board.

The size of the specular aluminum parabolic reflector is such as to amplify the bare lamp candlepower by about five times in the direction of the axis of the parabola.

Tests of the board are now underway at a number of elementary schools as well as universities.

Pilotless Jet Planes Recovered by Parachute at 600 Mph Speeds

Successful parachute recovery of some of the heaviest objects ever dropped at speeds up to 600 miles an hour has been accomplished by Ryan Aeronautical Company and the United States Air Force in extensive service tests at Holloman Air Development Center, Alamogordo, N. Mex.

Jet fighter pilots have been ejected from their cockpits in flight emergencies and dropped by parachute at equivalent speeds, but the weight of a pilot is only about a tenth as much as the articles used in the recent tests.

Through use of two comparatively lightweight parachutes, heavy loads have been carried to earth at near-sonic speeds in the Ryan–Air Force Test Program, conducted during development of the high-speed Ryan *Q-2* jet-propelled pilotless target airplane. These loads have been dropped undamaged at speeds far greater than those at which the military services regularly drop such heavy combat equipment as howitzers, jeeps and other vehicles, ammunition, and various types of weapons from cargo airplanes.

The Ryan *Q-2* high-performance jet target airplanes developed for the Air Force, Army, and Navy are being recovered intact after each test run, enhancing the economy feature of drones which thus may be repeatedly employed in air-to-air and ground-to-air target practice.

The remote-controlled Ryan pilotless airplane is about half the size of a jet fighter, can attain fighter speeds, and is designed to simulate fighter evasive tactics.

To obtain repeated use of the targets, a 2-stage parachute recovery system had to be designed. The "letdown" had to be accomplished without harm to the delicate equipment inside the *Q-2*. These requirements led to development of an entirely new parachute release system by Ryan and the Prevost F. Smith Parachute Company, Gillespie Field, El Cajon, Calif.

The main canopy is about half the weight of a conventional design parachute of comparable size. It billows out after release of a small "drag" parachute. Both parachutes are housed aft of the tail surfaces of the drone. This location minimizes the possibility of fouling during deployment.

Here is how the system works: The small conical drag parachute container is automatically released; then the drag parachute flares out, bringing the first sharp deceleration of the *Q-2*.

After a given time interval, the main parachute container is released. The drag parachute pulls the main parachute container rearward, and the main parachute is deployed from a bag.

This deployment bag is used to insure that the suspension lines are deployed first before the parachute's canopy can deploy and inflate.

The tremendous pull by the drag parachute exceeds the rated tension which can be withstood by a frangible cord extending from the main parachute container to the lines at the vent of the main parachute.

After the cord breaks, the drag parachute then lowers the container and deployment bag of the main parachute, while the big job of lowering the drone is taken over entirely by the main parachute which keeps the target airplane level during the descent.

On impact with the ground, a swivel, serving as the link between the parachute suspension lines and the strong nylon webbing "riser" attached to the drone, is automatically disconnected.

Thus the parachute is separated from the *Q-2* immediately on contact with the ground. This is necessary to prevent damage to the target airplane by strong ground winds "picking up" the parachute and causing it to drag the drone.

Many improvisations and changes in parts were required before the system was perfected. For many months, the Ryan–Air Force Tests were made with a simulated target which duplicated the *Q-2* in general structure and weight. It consisted of a pipelike configuration. This provided a low-cost means of testing the parachute recovery system without damaging the more expensive *Q-2* targets.

After many launchings of this imitation *Q-2* from "mother" launch airplanes, engineers announced that the reliability of the aerial recovery system was fully established.

Wright Air Development Center personnel assisted Ryan engineers by providing design data, construction features, and corrective ideas. Other Air Force participation included the providing of launching airplane and crews, facilities of the special parachut section for repeated packing of parachutes and the ground services required for re covery of test vehicles after drops.

And at the Wright Air Developmen Center, parachute specialists from pas experience had the solution to a particularl annoying problem, that of parachut "burns," resulting in ruptures of the nylo during the swift deployment of the para chutes. This was overcome by placing newspaper in such a position as to serv as an antifriction device between the mai parachute canopy and the canvas deploy ment bag.

Information obtained by the Air Forc in these tests has been used to advantage i other recovery problems.

Conditions of the later tests were s extreme they could not possibly be dupli cated in actual use. When the test vehicle in its free fall, attained a speed of approxi mately 600 miles an hour, the drag parachut was released. A few seconds later, the mai parachute billowed out, and the imitatio drone dropped to the ground undamaged.

Typical of the problems that arose durin the long testing program was the prematur operation of the swivel disconnect mecha nism while the test vehicle was still in the air during Test 3. Both parachute deploy ments were satisfactory, but a few second after the main parachute opened, th automatic switch went into action causin the main parachute to become detached fron the test bomb, which fell free to the groun and was severely damaged.

By recovering maximum weights a maximum speeds, technicians simulated th most severe conditions—conditions not at tainable in actual service, because th instant a *Q-2* is launched in a target flight it begins consuming fuel and losing weight In the most extreme experiments the tes vehicle was ballasted to a simulated *Q-* flight with full fuel tanks.

Data on air speeds at deployment of th parachutes, rates of descent, and magnitud of oscillation were obtained by phot theodolite coverage of four stations, use c radar and plotting board, and a phot chase airplane.

A sequence timer assembly releases th parachute through a series of actions. Th timer assembly can be actuated by th "beeper pilot" who operates the remot control box on the ground, governing th target's flight.

A separate relay can be actuated from th remote-control box to release the parachute

The conventional parachute is made fla so that when it opens out the mouth of th parachute is nearly equal to its diamete The parachutes used on the *Q-2* are amon the few "formed" type proved successf for such use. The panels from skirt to ve are formed in the exact shape they tak when opened. This has resulted in co siderable weight-saving, a vital necessit since the exact-forming process requires u of less fabric.

The cloth itself is lightweight with trip tear strength. Because the mouth of th parachute is narrower than the outsi diameter, the canopy has a lower openi shock load, reducing the possibility damage to the parachute.

The standard guide surface or "drag

parachute, also formed, has a larger diameter than the mouth opening. The canvas used in this parachute also has an extremely high tear strength.

The *Q-2* parachutes must be of such a durable nature as to permit repeated use under the most critical conditions. They have demonstrated their rugged characteristics by successfully dropping very heavy objects at high speeds from high altitudes.

Since the many tests with the imitation drones, numerous successful recoveries have been made of the *Q-2s*, with virtually no damage to the delicate internal equipment.

The *Q-2* flight test program is continuing at Holloman Air Development Center. The parachute recovery system has been accepted by the Air Force as suitable for the *Q-2* pilotless airplanes and has been standardized.

Refrigeration Chemical Helps Electronic "Nose" Find Leaks

A nearly foolproof method of finding leaks in anything from a football to a complicated coil of pipe or a huge distillation tank has been developed with a gas that once served only as the cold-making agent in refrigerators.

The new test medium is Du Pont "Freon-12" fluorinated hydrocarbon which, under pressure, is a colorless, virtually nontoxic and odorless liquid, but which changes to a gas when released from pressure at room temperatures. Its use as a leak detector stems from its ability to seek out and escape through the finest openings in almost any material. The exact location of such leaks can be found quickly with an electronic device or a gas-burning torch whose flame changes color in contact with the nonflammable Freon.

Halide torches, small hand-held lamps in which methyl alcohol, acetylene, or propane burns with an almost invisible flame, have been used for many years to detect leaks of Freon in refrigeration systems. The sensitive flame turns green or blue-green in the presence of the gas, and experts can tell by the flame color just how big the leak is.

A more recent development is the electronic leak detector which is responsive to Freon or other gaseous halogenated compounds. The first of these was developed by the General Electric Company. Weighing only 17 pounds and approximately the size of a small portable typewriter, the General Electric unit is so sensitive that engineers say it can uncover a leak that would let only 1/100 ounce of Freon escape in a year.

Western Electric is supplying a "traveling detective" version of the electronic tester. This instrument is pulled along on overhead telephone cables and signals leaks which, if not detected and cleared, might impair telephone service.

To perform at top efficiency, most telephone toll or long-distance cables are filled with nitrogen or air under pressure and then sealed, thus keeping out moisture and providing an inert atmosphere for the maze of wires within the cable. To locate leaks which cannot be found economically by other means, Freon-12 fluorinated hydrocarbon is pumped into the cable to displace the nitrogen or air. The electronic tester, sensitive to Freon and riding the cable suspension strand like a monorail car, is pulled along the cable. When the Freon detector spots a leak, a signal is transmitted to the ground crew and repairs are made quickly and surely.

Before the electronic "sniffer" was developed, one of the methods used to find telephone cable leaks consisted of painting the cable with soap solution so gas escaping through a defect would show up as bubbles. That was a long, tedious job. The new electronic device and Freon permit faster inspection of cable at a money-saving rate of about 120 feet per minute.

Another use is in the testing of complicated pipe coils or pressure vessels too large and cumbersome to be filled with compressed air and dunked in a liquid bath where escaping bubbles would indicate leaks. Today, precision manufacturers carry out tests on tanks as high as a 2-story building by filling them with a mixture of Freon and air, then carefully inspecting likely leak points, such as joints, fittings, or welds, with one of the electronic "noses."

Leaks in smaller vessels sometimes are found by filling the vessel with a liquid or dye which leaves a telltale spot of moisture or stain at a leaky point. But that is often messy, perhaps even injurious to the material being tested. Freon offers a better, cleaner, safer test in such application—and without the need for auxiliary pressure-producing pumps. Freon fluorinated hydrocarbon provides its own working pressure, which are approximately 70 pounds per square inch under ordinary room temperatures.

With the increasing use of radiant heating systems in home and industry, the small, portable Freon detector is finding its way into the tool kit of the heating contractor. Instead of actually placing the heating system in operation to test its tightness—with the possibility of water damage to construction if a leak exists—many contractors are using the electronic "sniffer" to give a safe, reliable, dry test as soon as the piping is in place.

Drums Used to Speed Switch Production

This constantly revolving and rocking drum plays a key role in speeding production of mercury switches by Minneapolis-Honeywell Regulator Company. The drum tilts the switches to and fro some 11,520 times daily until 36,000 such cycles have been completed for each of the 1,000 switches it carries. The rocking action properly distributes in the glass tubes a lubricant necessary to assure free flow of the mercury. This in turn insures fast, positive electric contact

Miniature Robot "Brain" Developed for Farm Use

A miniature "ventilation analogue computer," small enough to be carried by hand, has been developed by Minneapolis-Honeywell Regulator Company research engineers to take the guesswork out of a perplexing farm problem—how to select the proper climate control systems for barns.

The new device is believed to be the first computer designed specifically for such agricultural use.

Proper control of ventilation, humidity, and temperature in barns to insure the health and productivity of livestock is a problem that is receiving increasing attention from universities, county agents, and farmers.

"The big problem up to now," said Dr. Waldo Kliever, Honeywell's research director, "has been the lack of an accurate

Miniature "brain" for farm use is this "ventilation analogue computer," being operated. Device automatically calculates whether a barn needs a temperature or humidity control system, and if so, what size. It is believed to be the first computer designed specifically for such farm use

method of determining what kind of control system should be installed in a given barn, since barns vary considerably as to the number of animals they house, type of construction, and climate. The new computer offers for the first time a quick, scientific solution to this problem."

The device works this way: Information such as the number of animals in the building, their heat and moisture input, the heat and moisture gain or loss from various parts of the building, is fed into the computer. It then automatically calculates whether the barn needs a temperature or humidity control system, or both, and tells what size ventilating system is required.

"It will also show that some poorly insulated barns cannot be controlled without supplemental heating," explained William McGoldrick, Jr., designer of the device.

He pointed out that this simple way of getting such information might be used also to determine the construction of future barns.

Electron Microscope Used in Study of Tooth Structure

An electron microscope which can enlarge 20,000 times is in use at Northwestern University dental school.

The new microscope will make visible particles only a few atoms thick and will allow Northwestern research workers to see a great number of molecules within the human tissues.

The power of the microscope is such that a 25-cent piece, if enlarged proportionately by the instrument, would be more than two city blocks in diameter.

The University scientists hope that study of the submicroscopic structure of both decayed and healthy teeth will ultimately furnish information leading to a solution of the problem of dental decay.

Northwestern's dental school is presently the only one in the world to have its own electron microscope devoted exclusively to the study of dental problems. With it, the dentists will be able to see details of tooth structure that were never before made visible.

For more than a century, dental research workers have been studying the structure and composition of the teeth with the optical microscope which has obvious limitations. The new microscope utilizes a beam of electrons rather than a beam of light to form an image that can be photographed.

Principal interest of the scientists will be centered on the study of enamel, the outermost layer of the tooth crown, and dentin, the innermost layer of hard tissue.

Enamel is the tissue first involved by decay and is the hardest tissue in the human body. When seen under the electron microscope, it appears not as a smooth surface, but as an array of pronglike crystals only a few molecules in length.

Electromagnetic Models Used in Determining Transient Voltages

A new and successful method of determining transient voltages in transformers by using electromagnetic models has been developed by the General Electric Company's Power Transformer Department.

With the model-testing method, great dividends can be obtained in size and weight reductions in large high-voltage power transformers.

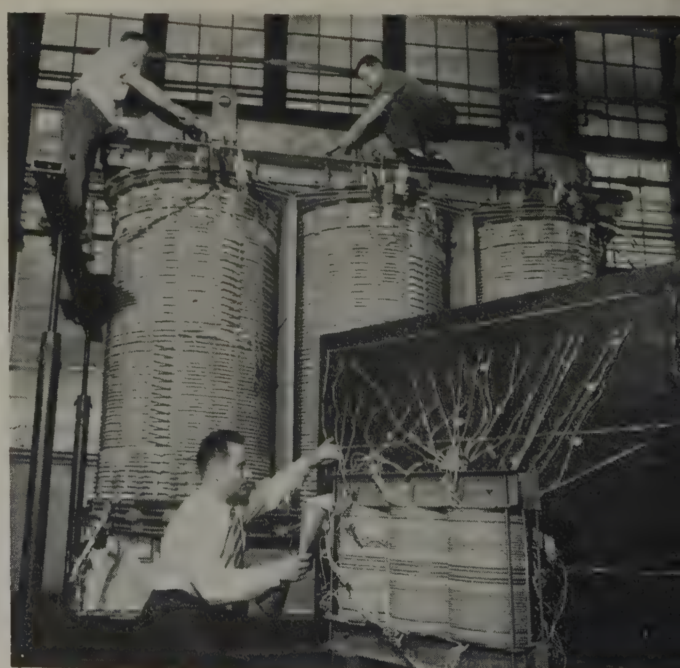
Answers on voltage magnitudes and waveshapes, vital information to transformer designers, are supplied accurately and simply by testing a model before the transformer itself is designed. These answers enable the designers to plan the construction of transformers with more efficient use of insulation and consequently more exacting use of materials and space.

The electromagnetic model reproduces faithfully the voltage magnitudes and waveshapes between any two points in a transformer, or applied waves of all types, and for all transformer connections. Its applications include: improvement of transformer designs; development of radically new winding structures; failure detection; and prediction of how a transformer behave[s] as a part of the power system.

On 11 models recently built and tested 238 measurements of the maximum voltage between corresponding points on the model and on the actual transformers showed an average deviation equal to only 4.3 per cent of the applied wave and to only 9.8 per cent of the voltage appearing on the transformer. This accuracy is more than adequate for design purposes.

Models requiring only a fraction of the time and cost of a large power transformer will be built for most transformers rated 100,000 kva and above, and all transformers having complicated winding designs.

Previously, to determine transient voltages exactly, it was necessary to test the full-size transformer with a transient analyzer. Any changes indicated on a completed transformer were expensive and time-consuming. Attempts also were made to determine transient voltages in transformers by geometrical models and equivalent circuits, but these methods proved to have definite shortcomings. The electromagnetic model combines the inductance effects of a geometric model with the capacitance effects of an equivalent circuit to give accurate results.



Shown is a 3-phase transformer, 33,333 kva, 115,000 to 37,090Y to 4,160 volts and its electromagnetic model. The model is 1/6th the size, 1/216th of the weight, and was available in 1/10 the time of the actual core and coils

Zirconium Is Vital Ingredient in Submarine Nuclear Reactor

For water-cooled nuclear reactors, such as the submarine reactor being built by the Westinghouse Electric Corporation, zirconium is one of the best materials that can be used. Iron, steel, aluminum, and other metals of normal strength and permanence are not suitable.

Zirconium is a metal lighter than steel. It has remarkable corrosion-resistance, an extremely high melting point, and is a fine structural metal in that it is quite strong and workable. Most important for its use in a nuclear reactor is the fact that it does not waste neutrons—the atomic particles tha[t]

split uranium atoms and keep the atomic engine running. Whereas some metals absorb these neutrons and thus interfere with atomic fission, zirconium offers no such interference.

These qualities make zirconium only second perhaps in importance to uranium in the building of the Westinghouse submarine reactor.

In 3 years of concentrated research, quantity production of zirconium that is 99.9 per cent pure has been achieved. Purity with respect to certain elements is the key to zirconium's resistance to corrosion and to the ductility of the metal.

The Westinghouse zirconium production process began with what is called zirconium sponge—porous chunks of metal that look like coke. The sponge is the result of a 6-step reduction process that begins with the zirconium-bearing sands from the ocean beaches. While relatively pure, zirconium sponge still contained impurities which had to be removed before the metal could be used successfully in the first submarine nuclear reactor.

The sponge was loaded into a big tank which also held a container of zirconium tetraiodide—a combination of zirconium and iodine. The head or top cover of the tank from which was suspended a series of 4-foot-long hairpin-shaped zirconium wire filaments then was put in place. After the tank had been heated in a salt bath and evacuated, electric current was passed through the zirconium wire. This started a chemical reaction.

The brick-red substance known as zirconium tetraiodide vaporized and deposited pure zirconium on the hot wire filaments. The freed iodine then migrated back to the remaining sponge material and the cycle began once again until a considerable thickness of zirconium was deposited on the wire hairpin. When the hairpin was removed finally, it was an irregular, hexagonal bar of super-pure zirconium that shines like silver.

These 4-foot-long crystal bars were rolled, then chopped into small pieces, and melted down into ingots. The ingots themselves eventually were forged and rolled.

IRE Convention Attracts Over 35,000 Engineers

More than 35,000 engineers, representing nearly every country in the western world, attended the 41st annual convention of the Institute of Radio Engineers (IRE), March 23–26, 1953, New York, N. Y.

The technical program of over 200 papers discussed the latest advances in color television, guided missiles, medical electronics, transistors, ultrahigh frequency, and computers.

A feature of the convention was the exhibition of electronic apparatus, which revealed scientific developments of over 400 of the country's leading research laboratories and manufacturers. Exhibits ranged from devices which use transistors in place of radio tubes to a full-sized ultrahigh-frequency television station.

Brigadier General David Sarnoff, chairman of the Board of the Radio Corporation of America, was guest speaker at the annual dinner of the IRE, March 25. He told them that their future in radio, electronics, and television is fascinating and promising, and that even their wildest dreams cannot encompass all the possibilities open to them in the years ahead. The fields of conquest in radio-electronics, he declared, are unlimited. General Sarnoff also was awarded the IRE Founders Award for his outstanding contributions to the radio engineering profession.

First floor of the exhibition held by the IRE during their 1953 National Convention. Over 400 manufacturers were represented at the exhibition

The 1953 Medal of Honor of the IRE was presented to Dr. J. M. Miller, Naval Research Laboratories, Washington, D. C., for his pioneering scientific and engineering contributions. Forty-nine members of the IRE were honored by elevation to the fellow grade of membership.

Arc Rod Used for Cutting, Melting Nonconductive Material

A new, patented process for cutting and piercing stone, cement, concrete, and refractory materials, trade named "DynArc," was demonstrated recently by the ChemoTec Division of Eutectic Welding Alloys Corporation, Flushing, N. Y. An arc rod was used for the first time upon nonconductive material and without a ground connection.

The DynaTrode creates its own arc. It requires no ground and it does not have to be struck upon metal. The operator has complete control at all times and he alone determines when and where the arc will start. This is not the only departure from the conventional. The arc, which will operate in mid-air as well as it will upon stone, resembles a flame in appearance. It has all the characteristics of a super torch flame from 5 to 8 inches in length.

Technically, DynaTrode is a self-energizing arc rod. The heavy coating, especially formulated to give the thermochemical interreaction with the arc stream to react with the nonmetallic material, is reduced more slowly than the core. This forms a crucible or tube of coating through which the tremendous energy is concentrated into a fine tip and its character has been changed by the disintegrating coating. The thermal ionization of the coating by the arc stream combined with the concentration produces the conditions necessary to pierce and melt the refractory material.

These are properties of formulation and electrical and thermal equilibrium which produce a predetermined thermochemical interreaction between the process of electrode disintegration and the components of the refractory material.

Wherever a d-c welding machine of 400 amperes or more capacity is available, the DynArc process may be used. The multiplicity of equipment associated with high temperature and pneumatic cutting and drilling is conspicuously absent. No compressors, air lines, oxygen tanks, pneumatic drills are necessary. A conventional welding machine and a supply of DynaTrode rods are all the equipment required.

Pilotless Drone Aircraft Used as Target for Defense Weapons

Details of one of the nation's newest pilotless target drone aircraft, the Ryan *Q-2* "Firebee," have been released by the United States Air Force's Air Research and Development Command as the first announced development of its kind to emerge from the nation's huge guided-missiles program. The drone is somewhat less than half the size of present-day jet fighters and has performance characteristics that simulate jet aircraft now in combat in Korea.

In the high-speed class, the Firebee, which can operate at high altitudes, is powered by a Fairchild *J-44* turbojet engine of about 950 pounds thrust. The engine is approximately 6 feet long, 22 inches in diameter. The mid-wing all-metal robot has sharply swept back wings and tail surfaces. It has an approximate 12-foot span and 18-foot length. It weighs about 1,800 pounds.

The near-sonic speed, recoverable drone has been under test for the past 2 years at the Air Research and Development Command's Holloman Air Development Center, Alamogordo, N. Mex. The Firebee is a joint project of the Air Force, Army, and Navy, with the Air Force's Air Research and Development Command having the responsibility for technical aspects of its development. Engineers of this Command's Wright Air Development Center, Dayton, Ohio, assisted the Ryan Aeronautical Company, San Diego, Calif., in developing the drone.

The principle mission of the Firebee which has been revealed is its use as a drone target for modern defense weapons. It is designed to offer a high-speed target capable of simu-

lating piloted jet airplane maneuvers for the training of antiaircraft crews. It is equally adaptable for ground-to-air tracking and firing and for air-to-air interception problems.

The Firebee is operated from a "black box" remote control station where a small control stick, and switches needed to change engine speed and other flight conditions, transmit command signals to the "nolo" (no live operator) aircraft. It can be flown out-of-sight and at high altitudes.

In order to achieve the most economical employment of the *Q-2* through its repeated use as a drone, Ryan Aeronautical Company and Air Force technicians from the Wright Air Development Center developed a 2-stage parachute system to decelerate the drone from its near-sonic operating speed and lower it safely to the ground without damage to the aircraft structure or the delicate electronic controls.

The recovery system is capable of lowering the drone to the ground automatically in the event of drone hit, loss of radio wave carrier from the remote control station, engine failure, or upon command by the remote control operator. There has been a high percentage of completely successful recoveries of actual drones during flight. In order to prevent damage to the target by ground winds dragging the Firebee after recovery, the parachute system incorporates a ground disconnect system which causes the parachute to become detached from the drone upon contact with the ground.

In the test program at the Holloman Air Development Center, the Firebee has been launched on numerous flights both from the belly and wings of twin-engine "mother" aircraft. It has also been successfully launched from the ground.

While most of the flights of the drone have been made with the Fairchild *J-44* engine, the drone has been tested also with the *J-69* Marbore *11* jet engine, developed in France by Turbomeca and scheduled to be manufactured in the United States by Continental.

The Ryan drone is composed of five major assemblies: fuselage, nacelle, wing, empennage, and parachute container. Construction is of aluminum, magnesium, and stainless steel.

For ease of assembly and maintenance in the field, the Firebee design incorporates many novel features. The wings attach to the fuselage with four readily accessible bolts. The nacelle containing the Fairchild *J-44* engine is hinged to permit ready access to the interior of the compartment. Like the wing, the tail assembly is attached with four self-aligning bolts.

The normal problems of design for a man-carrying jet airplane were present in development of the drone and, in addition, the complete development of a remote control system, an autopilot system, and a parachute recovery system were required.

Glide flight tests of the Firebee without power were begun in March 1951 with the first powered flights made that summer. While the basic research and test program is continuing at Holloman Air Development Center, the Ryan Aeronautical Company is training Air Force and Army ordnance officers and technicians in assembly, operation and maintenance of Firebees preparatory to "operational suitability testing" of the drones at several bases.

College Placement Bureaus Urged to Guide Veteran Engineers

The Engineering Manpower Commission (EMC) has launched a program to insure that the engineering graduates now in the Armed Forces and those who will be in uniform this year are kept informed of the means to obtain proper placement information upon leaving the armed services.

In announcing this program, Dr. T. H. Chilton, chairman of EMC, has urged all Deans of Engineering Colleges to encourage and support adequate placement services in their schools. Since a very high percentage of new engineering graduates are going directly into the military, Dr. Chilton stated that placement information should be taken into the armed services to facilitate employment upon separation. He also urged the Deans to place this information on college bulletin boards.

The Engineering Societies Personnel Services, Inc., the EMC Chairman pointed ou[t] is ready to aid all engineers whether they b[e] Society or non-Society members. Engineer[ing] Societies Personnel Service offices ar[e] located at 8 West 40th Street, New York[,] N. Y.; 80 East Randolph Street, Chicago[,] Ill.; 100 Farnsworth Avenue, Detroit[,] Mich.; and 57 Post Street, San Francisco[,] Calif.

Members of constituent societies in Engineers Joint Council have been urged to us[e] college placement services and the Engineering Societies Personnel Service as sources o[f] placement information, and to assist othe[r] engineers to use these facilities. Assistanc[e] to young engineers who have never bee[n] affiliated with any engineering society an[d] who went into the services immediately afte[r] graduation is stressed.

The purpose of this program is to remin[d] returning engineers, and industry, that th[e] common meeting grounds for them is eithe[r] at the college placement bureaus, or a[t] Engineering Societies Personnel Service.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication her[e] in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Force on a Conductor in a Slot

To the Editor:

The following interesting quotation is submitted as a supplement to the writers' letter in *Electrical Engineering* for May 1952 (*p 485*), which reported on a theoretical and experimental investigation of the forces on the iron and on the copper when a current-carrying conductor was enclosed in an iron sleeve, the combination being placed in a magnetic field. The finding was that the sum of the forces on iron and copper was the same as the force on the copper alone in the absence of the iron, but that depending on the permeability of the iron, most or effectively all of the force was exerted on the iron sleeve. The conclusion was that torques in machinery may be calculated using conductor currents and air-gap flux densities, even though the flux density in the conductors is only a small fraction of the air-gap density, but that the torque thus calculated is exerted principally on the iron of the rotor directly, rather than on the conductors and thus on to the rotor.

Subsequent to the writing of the letter, Dean R. A. Galbraith, of the L. C. Smith College of Engineering, Syracuse University, referred the writers to a 1929 Oxford University Press book by B. Hague[1] for a discussion of machine forces, and shortly thereafter Fitzgerald and Kingsley published their "Electric Machinery" with a reference to Hague. In addition to theoretical analysis, Hague presents some historical information which, while it will be familiar to a few of the older members of the Institute, most probably will be unfamiliar and quite interesting to many of the rest of the membership. The following then is quoted from pages 157–8 of Hague's book:

"The phenomenon discussed in th[e] preceding paragraphs is one of the mos[t] remarkable in the whole of electromagnetism and one of the greatest practical importance[.] By the marvellous properties of the ethe[r] the mechanical force is removed from a[n] embedded conductor almost completel[y] and is laid upon the iron mass; the tota[l] force upon the iron and conductor togethe[r] is exactly the same as if the wire wer[e] brought out of the iron into the air, th[e] impressed magnetic field being kept un[-]changed.

"In the early days of electrical engineerin[g] dynamos and motors were built with smoot[h] cored armatures, the armature conductor[s] being laid upon the surface of the iron cor[e] and secured thereto by bands of bindin[g] wire. In small machines this friction gri[p] was adequate to transmit the tangentia[l] force, but in larger machines a more positiv[e] drive was attained by the insertion of woode[n] driving pegs into the core, upon which th[e] torque could be exerted. Since the con[-]ductors lay upon the core-surface directl[y] under the influence of the field magne[t] poles, the electromagnetic force cam[e] entirely upon the conductors themselve[s] and was transmitted to the core plates an[d] thence to the shaft by friction or by pressur[e] on the pegs as the case may be.

"About 1895 it became common practic[e] to build armatures with slotted cores, wit[h] the object of utilizing the teeth intervenin[g] between successive slots as driving-peg[s]

It should be noted, however, that the principle of the slotted armature had been introduced by Pacinnotti in 1860, was then forgotten, and later reinvented. The armature winding was sunk into slots or even wound in closed tunnels cut in the iron core, and many argued that as the conductors *necessarily* lie in a magnetic field weaker than that just under the pole face, the torque on the armature must *certainly* be less than if the core were smooth with the wires upon the surface. Upon making the test it was found that with the same number of conductors, the same current, and the same air-gap flux density, the torques in the smooth-cored and in the slotted-cored armatures were exactly the same.*

"To the engineers of that time, not familiar with Maxwell's work, the problem offered by this phenomenon was most perplexing. The columns of the technical press of the nineties contain many papers and much correspondence discussing the theory of the matter and endeavouring to explain the paradox. It was, however, reserved for Dr. Searle in 1896 to publish the exact solution given in the preceding pages, and for DuBois to give some remarkable experimental confirmations of its truth.

"Dr. Searle's discussion effectively showed that when an armature winding is put into slots or tunnels instead of on the surface, the conductors certainly experience a force much less than before. But the iron of the core supports a tangential force, which, together with the force on the conductors, comes exactly to the force which the conductors would experience if laid on the surface, all else being unchanged.**

"* A simple contrivance for demonstrating the force on an embedded conductor is described by L. Fleischmann, "Versuchsanordnung zum Nachweis der elektromagnetischen Kraftwirkungen bei Nutenankern." *Elektrotechnische Zeitschrift*, volume 32, 1921, page 287.

"** For a simple experimental verification of this fact see J. H. Morecroft and A. Turner, "Forces on Magnetically Shielded Conductors." AIEE *Journal*, volume 48, 1929, pages 25–7."

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REFERENCES

1. Electromagnetic Problems in Electrical Engineering (book), **B. Hague.** Oxford University Press, London, England; Humphrey Milford, 1929.

2. Electric Machinery (book), **A. E. Fitzgerald, Charles Kingsley, Jr.** McGraw-Hill Book Company, Inc., New York, N. Y., 1952.

D-C Motor as Capacitor

To the Editor:

In my article on "The D-C Motor as a Capacitor" (*EE, Feb '53, pp 154–5*) I had traced the idea to 1932. Professor E. T. B. Gross of the Illinois Institute of Technology has written to me tracing it to the 1923 edition of the book "Elektrische Schaltvorgange" by Rudenberg; and P. F. Arseneau of the General Electric Law and Patent Services Department has called attention to the 1950 English-language edition of that book, "Transient Performance of Electric Power Systems" (McGraw-Hill Book Company), page 232.

E. E. Moyer of the International Business Machines Corporation writes appreciatively, mentioning also an AIEE conference paper by W. S. Kupfer and himself on "Synthesizing the Armature Circuit of a D-C Shunt Motor Supplied by Half-Wave Rectifiers" presented at the 1952 AIEE Winter General Meeting. He also gives credit to Max Whiting of the General Electric Company for a crane-motor control application of the d-c motor, the performance of which can be explained as a capacitance effect.

I thank all these gentlemen for helping enlarge the bibliography of the subject, but I also wish to point out that, as my 2-page article was only expository and did not claim an original discovery, it did not call for much more than a few references of historical interest, such as the 1923 German reference and the 1932 English reference. It may have been a mistake on my part to have given the few additional references that I did give in the bibliography of the article, thus exposing myself to the likely criticism—why not give all these many other references too?

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NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCED MATHEMATICS IN PHYSICS AND ENGINEERING. By Arthur Bronwell. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1953. 475 pages, charts, diagrams, 9¼ by 6½ inches, bound. $6. Fundamental physical laws in many of the more important fields of physics and engineering are expressed in general form by mathematical formulations, forming a basis for the development of numerous applications. The text shows how these fundamental formulations simplify to special cases which often form the starting point in the solution of problems. The underlying unity in the methods of mathematical analysis in the various fields is emphasized. Emphasis is also placed on applications in dynamics rather than in statics: heat flow, fluid dynamics, electromagnetic theory, vibration in mechanical and electric systems, and so forth. Solutions are given of typical problems.

BASIC ELECTRONIC TEST INSTRUMENTS. By Rufus P. Turner. Reinhart Books, Inc., 232 Madison Avenue, New York 16, N. Y., 1953. 254 pages, diagrams, illustrations, tables, 9¼ by 6¼ inches, bound. $4. A broad, comprehensive list of instruments is treated covering the radio, television, and general electronics fields. Basic principles, construction, operation, and practical applications are discussed in such a manner as to be useful to the technician, service man, or engineer. For aid in proper selection for use as well as to provide a logical treatment, the instruments are dealt with in 16 classified groups—simple meters for current and voltage, vacuum-tube voltmeters, inductance checkers, frequency-measuring devices, oscilloscopes, and so forth.

BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS, 1835–1951. Prepared by Committee *B-4* on Electrical-Heating, Resistance, and Related Alloys. American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa. (S.T.P., number *56-G*), 1952. 258 pages, 9¼ by 6¼ inches, bound. $5.50. Over 1,500 references, many including extensive abstracts, are listed in chronological order. They cover contact materials and methods of testing and the interruption of electric circuits. This new edition contains the items listed in the 1944 edition, those in the subsequent annual supplements, and new material since the last supplement. Both books and magazine articles are included, and subject and author indexes are provided.

ELECTRICAL MEASURING INSTRUMENTS. Part I: General Principles and Electrical Indicating Instruments. By C. V. Drysdale and A. C. Jolley. Revised by G. F. Tagg. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1952. 598 pages, charts, diagrams, illustrations, tables, 9 by 6 inches, bound. $12.50. Beginning with general electrical principles and typical basic systems, this standard work continues with the mechanical design and construction of instrument mechanisms and the elements of electrical theory and design. The following types are dealt with in detail: permanent-magnet moving-coil instruments; soft iron instruments; dynamometer ammeters; volt meters, and watt meters; hot wire instruments; electrostatic instruments. Separate chapters are devoted to the conditions of rapid indication and the properties of electrical materials. Although electronic techniques are intentionally given only brief mention, other advances, since the earlier edition, in design, construction, and performance have been given full consideration.

ELECTRICAL UNITS. By Eric Bradshaw. Chapman and Hall Ltd., London, England, 1952. 64 pages, diagrams, tables, 8¾ by 5¾ inches, bound. 9s6d. The primary purpose of this book is to explain the basis and use of the Meter, Kilogram, Second, Rationalized System of Electrical Units. Other systems of units in common use are described in relation to this system. Appendixes contain a brief reference to 2-dimensional field plotting, a listing of conversion factors (from one system to another) and the relative sizes of units, and a few other specialized topics.

A "FIRST BOOK" ON FIRE SAFETY IN THE ATOMIC AGE. By Horatio Bond. National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., 1952. 72 pages, charts, illustrations, 8 by 5½ inches, bound. $3. Essentially a discussion of the modifications and additions to peacetime fire-safety measures which will be necessary in attempting to achieve effective control of atomic-bomb fires. The author deals briefly but clearly with primary and secondary fire effects, with proper construction and location of buildings, and with both passive and active prefighting methods. A considerable bibliography is included.

HIGH SPEED PHOTOGRAPHY. By George A. Jones. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 311 pages, diagrams, illustrations, 8½ by 5½ inches, bound. $6.50. A comprehensive presentation of broad fundamental theory, practical operative techniques, and technical applications. Detailed descriptions are given of the light-generating and the photographic equipment for both still and motion pictures. A wide range of scientific, industrial, and commercial applications is covered, with the special requirements and limitations in each case. The book is well-illustrated and contains extensive lists of references.

LOW-TEMPERATURE PHYSICS. (National Bureau of Standards Circular *519*). 1952. 291 pages, charts, diagrams, illustrations, tables, 9¼ by 6 inches, bound. Order from Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.75. A group of some 60 relatively short papers most of which deal with some specialized aspect of the field: characteristics, properties, or behavior of an element or other substance; methods for the measurement of physical quantities or attributes at extremely low temperatures; descriptions of research activities. A considerable proportion of the papers deal with superconductivity effects, including a few theoretical treatments of a general nature. In some instances abstracts only have been printed.

ACOUSTICS IN MODERN BUILDING PRACTICE. By Fritz Ingerslev. Architectural Press, London, England (distributed in the United States by British Book Centre, 122 East 55th Street, New York 22, N. Y.) 1952. 290 pages, charts, diagrams, illustrations, tables, 8¾ by 5¾ inches, bound. $7.50. This introduction to architectural acoustics also gives a number of examples of practical solutions to acoustical problems, and should prove of interest to engineers as well as architects. The author, personally associated with this field of research in Denmark, here describes the basic principles of acoustics, and then discusses in some detail the transmission of air-borne and solid-borne sound and vibrations and the control of noise in air-conditioning systems. The treatment is more from the practical than the theoretical point of view.

PHOTOCONDUCTIVITY IN THE ELEMENTS. By Trevor Simpson Moss. Academic Press, Inc., 125 East 23d Street, New York 10, N. Y., 1952. 263 pages, tables, 8¾ by 5¾ inches, bound. $7.00. This book deals with the phenomenon of electronic conductivity by illumination in insulators and semiconductors. Part I discusses the theory of the electrical and optical properties of the nonmetallic elements, and Part II reviews these properties and effects in 12 elements including germanium and antimony. Much of this material is the result of the author's experimental work in conjunction with a dissertation. A bibliography is included.

RADIO SPECTRUM CONSERVATION. By the Joint Technical Committee of the Institute of Radio Engineers and the Radio-Television Manufacturers Association. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 221 pages, charts, 8¼ by 5¾ inches, bound. $5.00. This report presents the point of view that the radio spectrum is a public resource requiring efficient conservation and use the same as forests or mineral resources. It begins with a historical survey reviewing the development and increasing use of the radio spectrum. Succeeding sections summarize propagation characteristics, present an ideal allocation table, offer specific suggestions to bring the actual allocation in line with the ideal, and give an extensive bibliography.

STATISTICAL THEORY IN RESEARCH. By R. L. Anderson and T. A. Bancroft. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 399 pages, tables, charts, 9¼ by 6¼ inches, bound. $7.50. This book was designed to serve as a reference work for research workers as well as an advanced textbook in the study of applied statistics. It is divided into two parts, the first of which presents basic statistical theory such as probability, population, and sampling theory, point and interval estimation, and the uses of the chi-square test. Part II covers analysis of experimental models by least squares. A knowledge of the calculus is required for effective understanding of the material. The text is well illustrated with actual experimental data, and the necessary tables are appended.

SUPERCONDUCTIVITY. By D. Shoenberg. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., second edition, 1952. 256 pages, tables, charts, graphs, 8¾ by 5¾ inches, bound. $6.00. The experimental and theoretical aspects of superconductivity are presented in this monograph. Magnetic, thermodynamic, and other thermal properties are discussed. This second revised edition gives a detailed account of the recent work on the structure of the intermediate state, on penetration effects, on phenomenological theories, and on the attempts at fundamental theories. Many experimental and numerical data are given. A bibliography is also included.

SYMPOSIUM ON INSULATING OILS. By Committee *D-9* on Electrical Insulating Materials. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. (Special Technical Publication, Number 135) fourth series, 1952. 37 pages, tables, charts, 9 by 6 inches, paper. $1.00. This publication contains Parts II and III of a series of articles on the evaluation of mineral transformer oil during service: Part II—Correlation of oil characteristics with continued transformer operation; Part III—An examination of selected transformers. These symposia deal with studies on insulating oils being carried on in a number of laboratories.

METADYNE STATICS. By Joseph Maximus Pestarini. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 415 pages, charts, diagrams, illustrations, 9¼ by 6¼ inches, bound. $9. A metadyne is an electric machine provided with an armature having a commutator upon which bear at least three brushes per cycle of the machine, commutation being independent of the main windings of the stator or any eventual magnetic member acting upon the armature. The author, who is the original proponent of this new group of electric machines, presents logically and thoroughly the theory, design, and applications of metadynes, emphasizing that specific characteristics particularly suited to each application can be provided, rather than having to adapt existing equipment to performance requirements. Steady-state characteristics are covered in the present volume. A subsequent volume on "metadyne dynamics" is to cover transient characteristics when the machines are subjected to rapidly varying currents.

PRINCIPLES OF AERODYNAMICS. By Daniel O. Dommasch. Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y., 1953. 389 pages, 9¼ by 6¼ inches, bound. $7.50. The purpose of this text is to describe and define the physical laws which are basic to aerodynamics and the methods used to apply these laws to specific problems. Beginning with the stream function and other basic flow characteristics, the book proceeds with detailed analyses of various types of compressible and incompressible flow, ending with a brief discussion of viscosity effects. Mathematical operations are fully carried out, a chapter on vector operations and the complex variable being provided for those who need it.

QUALITY CONTROL AND INDUSTRIAL STATISTICS. By Acheson J. Duncan. Richard D. Irwin, Inc., 1818 Ridge Road, Homewood, Ill., 1952. 663 pages, 9¼ by 6¼ inches, bound. $9. Intended primarily as a college text, this book has been thoroughly indexed and cross-referenced for the practicing engineer and research worker. The chapters are sufficiently independent to allow them to be studied in any desired order. The chapter headings are as follows: fundamentals; acceptance sampling by variables; control charts; statistics useful in industrial research. Selected mathematical proofs, special tables, other helpful technical data, and a glossary are contained in appendixes.

THE RADIO AMATEUR'S HANDBOOK. By the Headquarters Staff of the American Radio Relay League, West Hartford 7, Conn., 30th edition, 1953. Various paging, 9½ by 6½ inches, paper. $3. This standard manual of amateur radio communications covers the entire field from the fundamentals to the latest techniques in equipment, design, and construction. The considerable amount of technical data provided includes a comprehensive, up-to-date section of vacuum-tube data tables. The advertising section contains condensed manufacturers' catalogues. As usual, the new edition has been revised to conform to current practice.

RADIOISOTOPES IN INDUSTRY. Edited by John R. Bradford. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1953. 309 pages, 9¼ by 6¼ inches, bound. $8. Based on a series of lectures presented at Case Institute of Technology, this book covers all of the important industrial uses of radioactive isotopes. The original material has been revised to include the most recent developments. Important related topics are also considered, such as laboratory construction, shielding, personnel protection, handling techniques, and radioactive waste disposal. This is a comprehensive treatment including the recently developed industrial uses of gross fission products.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Smaller Electric Machinery. New developments in lubricants and bearings which will make possible reduced-size electric machinery are described in a Government research report now available, released by the Office of Technical Services of the United States Department of Commerce. The report summarizing 5 years of work on this project indicates the best operating temperatures for glass-silicone electric motors and describes how these were arrived at. It also states how well older types of lubricants and the newer high-temperature greases stood up at these higher temperatures, and describes the apparatus and procedures used to make these tests. Included also in the report are: a Government specification on lubricants suitable for these high-temperature-operating electric machines; a discussion of the mechanism of lubrication at these higher operating temperatures; and recommendations for preparation of greases, for design of motor structures, and for design of motor bearings suitable for the high-temperature operation of silicone-glass insulated machines. *PB 111015*, "High-Temperature Lubrication of Electric Motor Ball Bearings," 84 pages, including tables, graphs, and photographs. $2.25 mimeograph copy. Orders should be addressed to the Office of Technical Services, United States Department of Commerce, Washington 25, D. C., accompanied by check or money order payable to the Treasurer of the United States.

Instrument for Spectrochemical Analysis. A fast, sensitive, and stable spectrophotometer for chemical analysis is described in a report released by the Office of Technical Services of the United States Department of Commerce. The report, on work done as a Navy research project and entitled, "A Recording Photometer and Accompanying Apparatus for Use in Measurement of Reaction Kinetics," indicates that the instrument's desirable characteristics are due in large part to a unique electronics servomechanism for balancing the solution and solvent light beams. This system is unique because both light beams are "chopped" by a rotating disk into light pulses which produce a pulsed electric current suitable for driving an a-c type of balancing system. The report also describes the optical system, a range selecting arrangement, and discusses the over-all sensitivity, stability, and precision of the spectrophotometer. 32 pages, including diagrams. Microfilm $2.25, Photostat $5. Available from Library of Congress, Photo-duplication Section, Washington 25, D. C. Enclose check or money order payable to the Librarian of Congress.

Standards for Wet-Process Porcelain Insulators. The Edison Electric Institute and the National Electrical Manufacturers Association have just published jointly the following standards for wet-process porcelain insulators: Standards for Suspension-type Insulators, NEMA Publication *140-1952;* Standards for Spool-type Insulators, NEMA Publication *141-1952;* Standards for Strain-type Insulators, NEMA Publication *142-1952;* Standards for Low- and Medium-Voltage Pin-type Insulators, NEMA Publication *143-1952;* Standards for High-Voltage Pin-type Insulators, NEMA Publication *144-1952;* and Standards for High-Voltage Line-post-type Insulators, NEMA Publication *145-1952*. Each of these publications contains information concerning material, dimensions, electrical and mechanical characteristics, markings, packing, sampling, inspection, and tests. 25¢ each. Available from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.